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Thank you

# Socio-economic Impacts of Solar Pumping System in Term of Local Job and Value Creation in Egypt

## Final Report

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# Glossary

| | |
|---|---|
| ANMW | National Agency for Energy Conservation |
| Capital Intensification or Coefficient of Employment | Size of investment in the sector divided over total labor in the sector. The result is the worker's share of investment in that sector. |
| Closed Drainage | Airtight or water-tight Drainage of a cavity through an opening in the chest wall into which one or more drainage tubes are inserted, the opening not being sealed against the entrance of outside air. |
| Crop Intensity | The fraction of the cultivated area that is harvested. The cropping intensity may exceed 100 percent where more than one crop cycle is permitted each year on the same area. |
| Deep groundwater | Groundwater located at a depth more than 7 m. |
| Groundwater | Water that occurs below the Earth's surface at depths where all the pore (open) spaces in the soil, sediment, or rock are completely filled with water. |
| New Land | Newly reclaimed Agriculture Lands which have been reclaimed relatively recently particularly since the construction of the Aswan High Dam or are currently in the process of being reclaimed and they are less fertile, which used modern irrigation methods such as sprinkler and drip irrigation and their productivity could improve. |
| Old Land | Agriculture Land in Nile Valley and Delta, which used traditional surface irrigation methods with very low field water application efficiency. |
| Open Drainage | Is a drainage of a cavity through an opening in the chest wall into which one or more drainage tubes are inserted, the opening not being sealed against the entrance of outside air. |
| Pedogenesis | Soil formation process (climate; living organisms; parent material; topography; and time). |
| PVP | Stands for Photovoltaic Pump. It is a complete set of components for powering irrigation water by solar panels by converting sunlight into electricity by the photovoltaic process, including the array and balance of system components. |
| Resettlement of Agricultural Investments' Coefficient | Agricultural Investment/Total Investment * Gross Domestic Product/Agricultural Domestic Product. |
| Shallow groundwater | Groundwater located at a depth less than 7 m. |
| Subsurface drainage system | Is a man-made system that induces excess water and dissolved salts to flow through the soil to pipes (closed drains) or open drains, from where it can be evacuated. |
| Surface | Is a system of drainage measures, such as open drains and land |

| | |
|---|---|
| drainage system | forming, to prevent ponding by diverting excess surface water to a collector drain. |
| Surface Water | Water on the surface of the planet such as in a river, lake, wetland, or ocean. It can be contrasted with groundwater and atmospheric water. |
| Water Users Associations | An organization whose members pool resources in a cooperative effort to manage, operate, monitor and maintain a water source or irrigation system |

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## Executive summary

The agriculture sector in Egypt is considered one of the significant contributor to the Egyptian Economy and in particular the rural economy. It takes over a share of 11.2% in the country's GDP in FY 2015 and the sector is maintaining a constant growth from FY 2014 by 3.0% yearly. Thus, the agriculture sector contribution to GDP at factor cost stood at LE 27.5 billion in FY 2015. The most recent agricultural land surveys indicates that there are 9.73 Million Feddan* in the Nile Valley and Delta area and 3.10 Million Feddan in new reclaimed areas within the last three decades with a total of 12.83 Million Feddan all over the country. Agriculture economy is representing 20% of total exports in Egypt. There are several industries relies on Agriculture such as harvesting, processing, marketing and supply chain that can account for further 20% of GDP and accommodate around 30% - 40% of labor force. Crop production contributes about 66% of the total value of agricultural GDP. On per capita basis, Egypt's area of cultivated land is owned by about 5.4 Million farmers who own 9.73 Million Feddan in the old land and 0.341 Million farmers who own 3.10 Million feddan. Farm sizes are small with an estimated 40 percent of holdings owns less than 1.0 Feddan.

Egypt is endowed with 4 main agro-ecological zones having specific attributes of resources base, climatic features, terrain and geographic characteristics, land use patterns and socio-economic implications. The Egyptian irrigation system is considered a "closed system" that has main inlet which is the Nile River and other minors resources represented in the rainfall in the coastal zone and the deep groundwater in the desert. A complete network canals and drains are extended from south at Aswan to the Mediterranean Sea. The cultivated areas are served by around 31000 km of public canals (1000 km of main canals and 30000 km of secondary canals), 80000 km of field channels (Mesqas), and 17000 km of public drains. The irrigation system of Egypt makes it possible for a year round cropping.

Because the water level in the system is below field level in most of the area, the water has to be raised through diesel pumps (or the traditional water wheels). In some areas, the farm intakes are receives water directly from the distributaries. Besides the gravity diversion of Nile water, water is also diverted by major pumping stations along the Nile and its branches. The Ministry of Water Resources and Irrigation is operating the pump station system for irrigation and drainage network with about 1000 pumps. These pumps are responsible for lifting water from low level waterway to the higher level. 600 Pumps are operated also by the Ministry of Water Resources for lifting water from groundwater wells mainly in El-Wadi El-Gedid and the Oasis areas. Then, the surface irrigation is practiced in the old lands combined with water lifting systems, while pressurized irrigation–sprinkler and localized irrigation are compulsory by law on the new lands. The latter uses a cascade of pumps from the main canals to the fields. In addition, farmers in the new lands are using new irrigation techniques for irrigation such as drip irrigation and sprinkler irrigation. This type needs specific equipment and pumps to operate the system.

Along the current study an inventory for the pumps used for irrigation in Wadi and Delta area and the new reclaimed lands that are used all over the country for irrigation has been concluded to be as follows: 233000 pumps in Wadi and Delta to lift from surface water, 40000 pumps in new land to lift from surface water, 46000 pumps to lift water from groundwater aquifers in Wadi and Delta and 30000 Pumps to lift water from groundwater aquifers in new land. Thus, the total number of pumps is 349000 pumps (76000 groundwater pumps and 273000 surface water pumps). Concerning the land tenure structure in Egyptian agriculture system it has been found from literature that Fragmentation of the agricultural land is a major characteristic of Egyptian agriculture, especially in the old land. It indicates a small size of the unit of production. Even in many places owner shareholding one land but divided into a number of plots, separated either by another holder's land, irrigation or a drainage canal. For category of holding less than one Feddan, it represents the largest category of holders with a range of 40% of the owners and their land is representing only 10% of the total land. For category of holding more than 1000 Feddan, the total number of owners is 212 farmers representing 0.003% of the owners while their land represents 7.7 % of the total land area. In case of the new land, the largest category of holders is holding less than one feddan are representing 20% while their lands are representing 1.8% . The total number of farmers who are holding more than 1000 Feddan are representing 0.014 % and their lands represent 4.8% of the total land area. In both the old and the new lands, the largest category of land holders is mainly in the age group of 45 years. The second largest group of land

holders is of age 50–60 years. The third group concerns the group of land holders between 30–40 years. The percentage of land holders for this age group is 23% and 25% in old and new lands, respectively. The remaining number of landholders is classified in the age group of less than 30 years.

The irrigation pumps in Egypt are operated mostly by Diesel Fuel while in some places farmers are using grid electricity in some locations. The most important issue is that the farmers in Egypt are irrigating day and night. The total number of pumps that can be converted to PV system is found to be 118000 pumps. Four categories of pumps are found in Egypt, these categories are 6 hp and this level is mainly used for lifting surface water. The second category is ranged between 6-12 hp and it is used for lifting surface water and water from shallow groundwater aquifers. The third category is 16 hp and more and this type of pumps is used for lifting water from groundwater aquifer. The fourth category is the pumps that are already operated by electrical motors and this category is used for groundwater and surface water depending on the location. Throughout the analysis it has been it has been found that El-Beheira governorate has the highest number of pumps to be converted to PV system with a number of pumps in the range of 36000 pumps. El-Sharkeya and Kafr El-Sheikh governorate are having a range of 11000 pumps for each. The number of available pumps that can be converted to PV system is representing only 4.0 % (on average) of the total number of pumps in Egypt. The highest market opportunity is located in Wadi El-Gedid area and the Oasis with a range of 75% on average level with a number of 1800 pumps. The number of pumps was estimated through modeling the land tenure level in accordance with the type of crops.

The intensive analysis shows that there are some crops that their benefit cannot cover the cost of converting to PV system such as wheat, cotton and barely. However, some other crops are giving a relatively high potential for covering the cost of assets specially vegetables such tomatoes, eggplant, okra, clover and fruits. It has been found that the optimum land tenure level is 10 Feddans and more. Below this level the farmer cannot cover the assets cost in two seasons. On the other hand, it has to be stated that the strategic crops with the current situation are considered not attractive to cover the asset cost of converting to PV system. For example, in order to cover the cost of converting to PV pump system for an area cultivated wheat it is in need of 20 Feddan at least, moreover it need 65 Feddan to cover the cost for cotton cultivation. Moreover, the system should consider the irrigation at day and night. The PV converting system is relatively very expensive if we consider the night irrigation through the storage battery system. Thus, all of the current study depends upon the use of the hybrid system, i.e. the PV only during day light.

The market study has been extended to develop a model for the future prediction for the market size. A 3rd order polynomial model based upon the solar power actual market growth in Europe, China, Asia, South pacific and Australia between 2000 up till 2015 has been developed. Several scenarios are formed and the results shows that the 118000pumps can be fully replaced by year 2030 if the system started by the current market potential of PV system in Egypt which is 1500 PV pump per year. Five other scenarios are developed by changing the start potential of the market by 2000, 3000, 4000, 5000 and 6000 PV pumps in the first year (2018). The market can fully satisfy by year 2028, 2027, 2027, 2026 and 2026 for the five mentioned scenarios respectively.

# 1. Primary and Secondary research including surveys of areas of agricultural area, irrigation practices and systems (river-based and ground water) to understand the status quo, the real needs and technical and the main challenges of the of the market.

## 1.1 Water Resources System of Egypt

Water resources in Egypt are represented with the quota from the Nile water; the limited amount of rainfall on the coastal areas; the shallow and renewable groundwater reservoirs in the Nile Valley, the Nile Delta and the coastal strip; and the deep (mostly non-renewable) groundwater in the eastern desert, the western desert and Sinai. The non-traditional water resources include reuse of drainage and wastewater, and desalination of seawater and brackish groundwater. After the completion of the HAD in 1968, Egypt started a new era of development through more controllable Nile water releases to different water users. Water users include agriculture, municipalities, industry, navigation, hydropower generation, and fisheries. For the time being, agricultural sector is considered the most water-consuming sector, as it consumes about 85% of the Nile water. Navigation and Hydropower generation are non-consumptive uses, as water releases are only needed to maintain their operating water levels. Recently, water demand for municipal and industrial sectors started to compete with agricultural water demand due to the rapidly growing population.

## 1.2 Egypt Irrigation Network

Egypt operates an ancient and spatially complex irrigation system. The schematic shown in Figure 2 presents a highly simplified view of Egypt's sources and uses of irrigation water from the Nile. The system hierarchy begins with the main-stem of the Nile. Principal canals receive water directly from the Nile, then deliver to branch canals and distributary canals. Private canals known as mesqas receive water from the branch canals or distributary canals, then deliver the water either directly to the fields or into smaller marwas, which are private deliveries from mesqas that convey water to fields located at a distance from the mesqa. The main canal diversions shown in the schematic include Asfon, Kelabia, East Naghammadi and West Naghammadi in Upper Egypt, while the Toshka canal takes water directly from Lake Nasser. Middle Egypt has two main canals. The Ibrahimia canal divides its water between many canals to serve irrigation in the Assiut region. The Ismailia canal irrigates the Suez and Elshrkia regions. In Lower Egypt, downstream of the Delta gauge, the Nile splits into two branches, Rosetta and Damietta, creating the Nile Delta. The Rosetta branch includes the Menufia, Beheira, Nasser and Mahmodia canals, while the Damietta branch includes the Tawfikia and Alsalam canals. There are about 30,000 km of public canals, 80,000 km of mesqas and drains and 670 large pumping stations for irrigation and dumping drainage water either into the sea, lakes or canals.

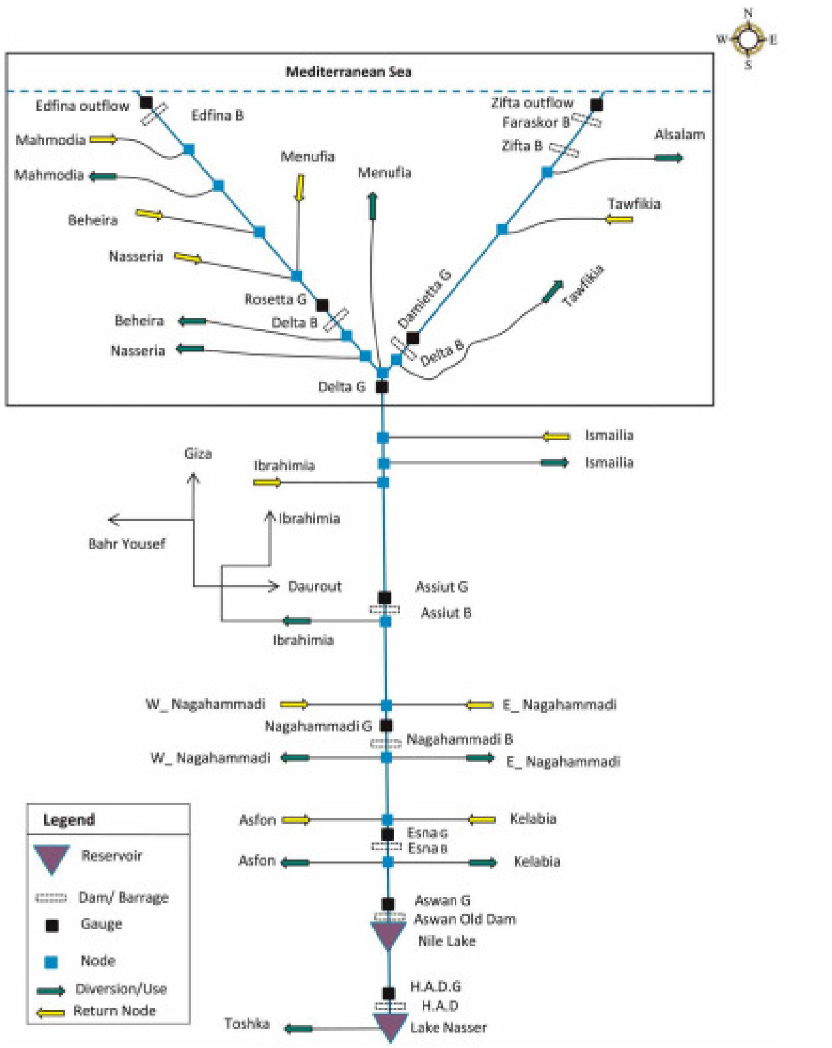


**Figure 1: Schematic Diagram shows the Irrigation Water Network of Egypt (River Stem and Main Canals)**

However, there are many hydraulic structures are existing in the Egyptian Network for irrigation and these structures can list in the following table.

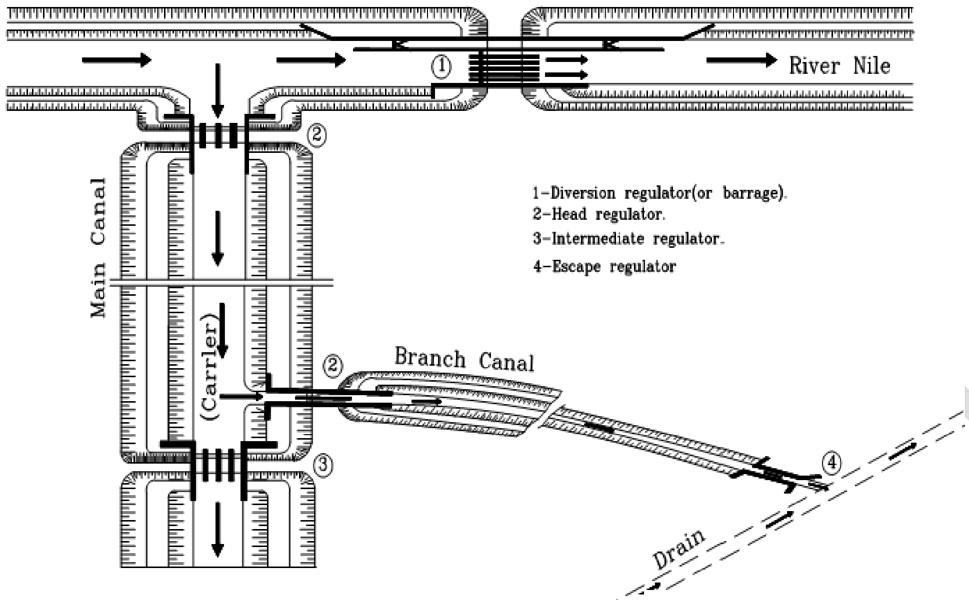


**Figure 2: A General Layout shows the Different Types of Head Regulators and the Technique of Carrying Water from the River to the Land through Gravity System in Egypt**

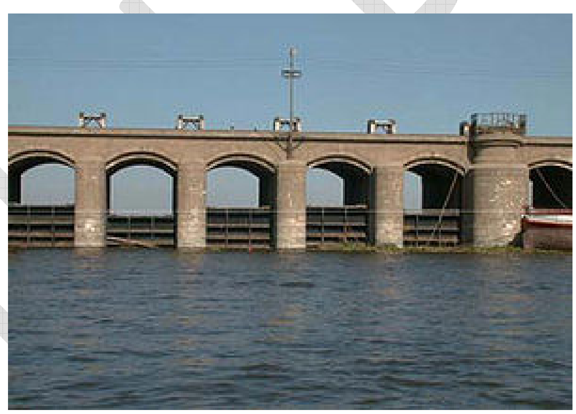

**Figure 3: A Front View for a Large Barrage on the Nile River showing the Control Gates for Water Flow**

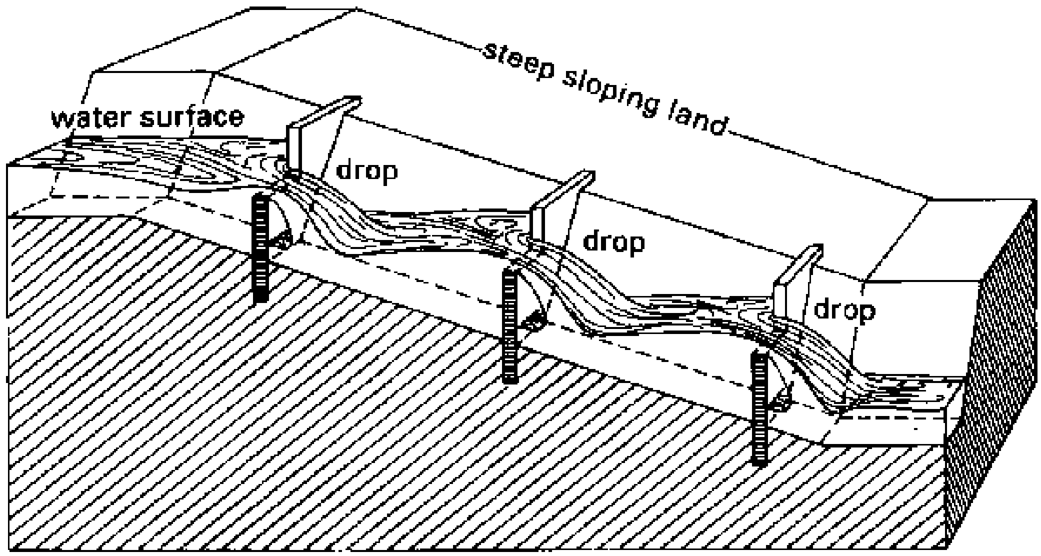


**Figure 4: A Sketch Shows a Longitudinal Section in a Steep Slope Land Controlled by Drop Structures (Weirs)**

## 1.3 Irrigation Procedure and Techniques in Egypt

In Egypt, the dominant irrigation method is surface irrigation, which covers approximately 83% of the irrigated areas. The rest lies under sprinkler (12.5%) and drip (4.5%).

### *1.3.1 Surface Traditional Irrigation*

In Egypt, irrigation water is distributed through a complex system where water started to be transferred from the Nile through the control structures as presented in Figure (2), then water is transferred from the main canal to the distributary canal or the minor canal until it reaches to the farm land for irrigation. On the average, each Feddan is usually irrigated on the average level by 20-30 $m^3$/day. This system is valid for almost all of the old lands of Egypt that are the wadi and delta where flood irrigation is the common type of irrigation. This wide spread implementation might be due to its low capital cost, no special technical experience regarding operation and maintenance is needed and no specific equipment are required as well as the long practical background among local farmers regarding usage of such system. On the other hand, surface irrigation among other methods has the lowest irrigation efficiency with 60%. Deep percolation particularly in the upper part of the irrigated field as well as the less-uniformity of irrigation water above soil surface are the main causes of the lower efficiency of surface irrigation. In average, losses of irrigation water under this method is about 45% causing several acute problems such as leaching of nutrient elements and raising of water table. Consequently, reduction in crop yield, crop-water and/or fertilizer productivity could be predicted.

The branch and distributary canals system is operated according to agricultural rotation principal. There are two systems of rotation; two-turn rotation and three-turn rotation. Under the two-turn rotation, the canal system is divided into two groups.

Each canal group is opened for 7 days and closed for another 7 days resulting in a length of irrigation interval of 14 days. Under the three-turn rotation, the canal system is divided into three groups. Each group is opened for 5 days and closed for another 10 days giving an irrigation interval of 15 days. The rotation system for rice is usually two-turn rotation with 4 days on and 4 days off. At the *mesqa*, distributaries receive water according to a rotation schedule. Water is pumped from the distributaries to irrigate fields (lift: about 0.5-1.5 m) Surface irrigation by rotation may give poor results and if a surface method must be used, sandier soils should be irrigated more frequently. Surface irrigation by rotation may give poor results and if a surface method must be used, sandier soils should be irrigated more frequently.


**Figure 5: A 6 Hp Pump to Lift Water from a Canal to the Mesqa**

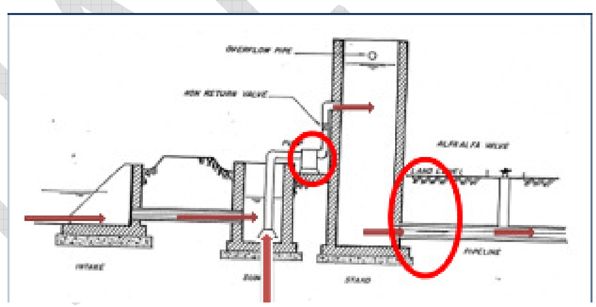

**Figure 6: A Sketch Shows the Applied System in Egypt to Transfer Water from the Canal to the Irrigated Land**

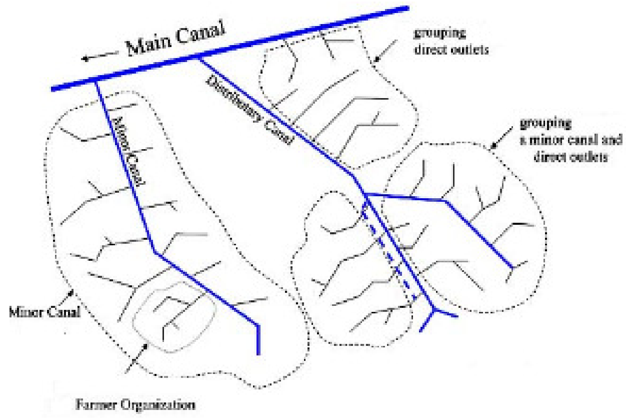


**Figure 7: A Sketch Shows the Canal Network System in Egypt**

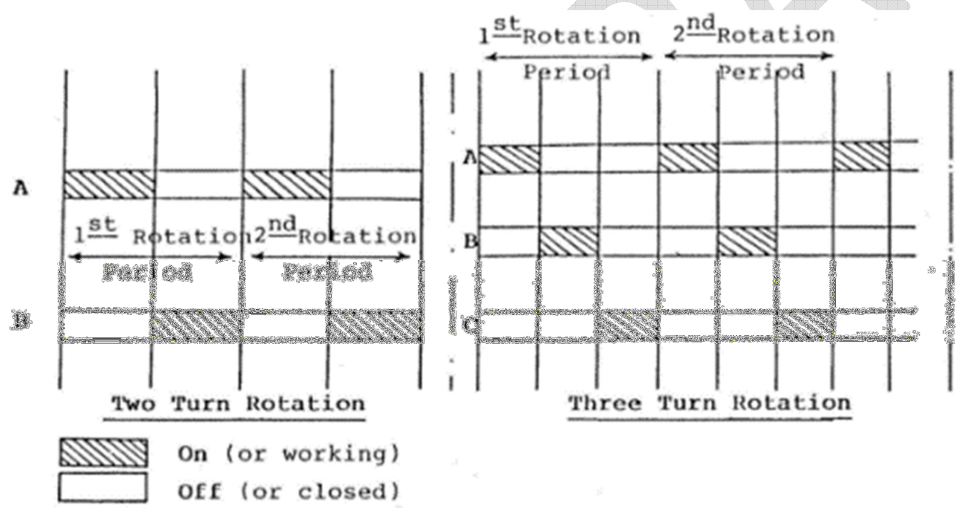


**Figure 8: Schematic Presentation of Irrigation Rotations**

### *1.3.2 Drip Irrigation and Sprinkler Irrigation*

Drip and sprinkler and irrigation usually have a much higher efficiency than surface methods

#### *1.3.2.1 Drip Irrigation*

Drip irrigation is a form of irrigation that saves water and fertilizer by allowing water to drip slowly to the roots of many different plants, either onto the soil surface or directly onto the root zone, through a network of valves, pipes, tubing, and emitters without any rotation. The system consists of pump unit, control head, main and sub-main lines, laterals and emitters or dripper.

The **pump unit** takes water from the source and provides the right pressure for delivery into the pipe system.

The **control head** consists of valves to control the discharge and pressure. In the entire system. It may also have filters to clear the water. Common types of filter include screen filters and graded sand filters which remove fine material suspended in the water. Some control head units contain a fertilizer or nutrient tank. These slowly add a measured dose of fertilizer into the water during irrigation. This is one of the major advantages of drip irrigation over other methods.

**Mainlines, submains and laterals** supply water from the control head into the fields. They are usually made from PVC or polyethylene hose and should be buried below ground because they easily degrade when exposed to direct solar radiation. Lateral pipes are usually 13-32 mm diameter.

**Emitters** plays as a device to supply very low flow rates (less than 10-15 1/hr.) to the top soil; through small holes in the emitters, which are placed near the crops on the soil surface water drips to the root zone. They are usually spaced more than 1 meter apart with one or more emitters used for a single plant such as a tree. Water moves both sideways and downward away from the point of application to form a "bulb" of wet soil. Also, it may be placed below the surface in order to protect the network from ultraviolet radiation for row crops more closely spaced emitters may be used to wet a strip of soil. Many different emitter designs have been produced in recent years. The basis of design is to produce an emitter which will provide a specified constant discharge which does not vary much with pressure changes, and does not block easily.

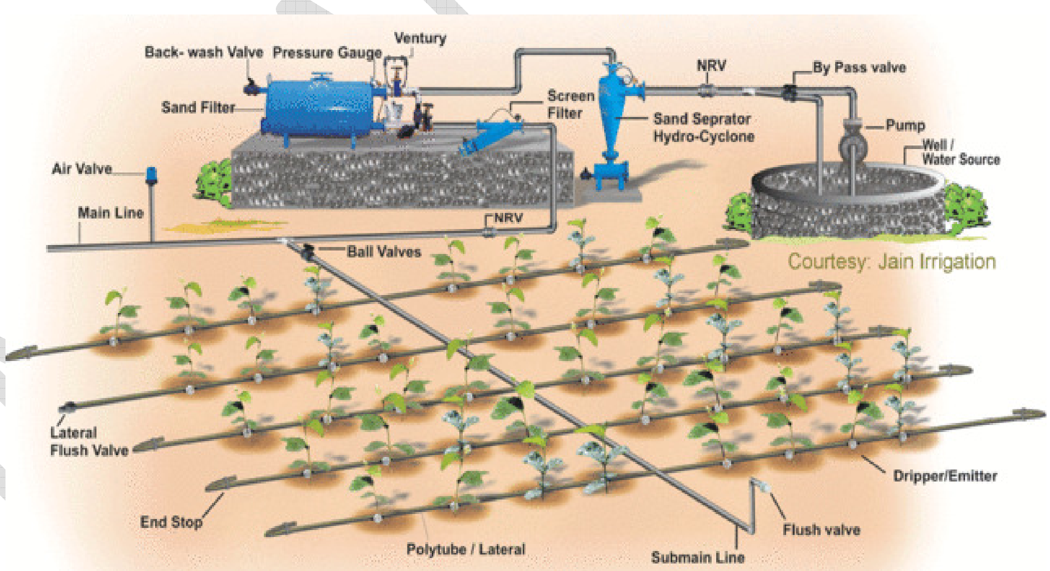


**Figure 9: Sketch of Drip Irrigation System Layout**

### *1.3.2.2 Sprinkler Irrigation*

In the sprinkler method of irrigation, water is applied above the ground surface as a spray somewhat resembling rainfall. The spray is developed by the flow of water under pressure through small orifices or nozzles. The pressure is usually obtained by pumping, although it may be by gravity if the water source is high enough above the area to be irrigated. The irrigation water is distributed to the field through pipelines. The pressure varies between 0.7 to 20 m for a flow rate of 0.7 and 100 $m^3$/h, respectively

The sprinkler system includes the sprinkler, the stand pipe, the lateral pipe, the main line pipe and often the pumping plant.

The **pump unit** is usually a centrifugal pump which takes water from the source and provides adequate pressure for delivery into the pipe system

The **mainline** - and **submainlines** - are pipes which deliver water from the pump to the laterals. In some cases these pipelines are permanent and are laid on the soil surface or buried below ground. In other cases they are temporary, and can be moved from field to field. The main pipe materials used include asbestos cement, plastic or aluminum alloy.

The **laterals** deliver water from the mainlines or sub mainlines to the sprinklers. They can be permanent but more often they are portable and made of aluminum alloy or plastic so that they can be moved easily.

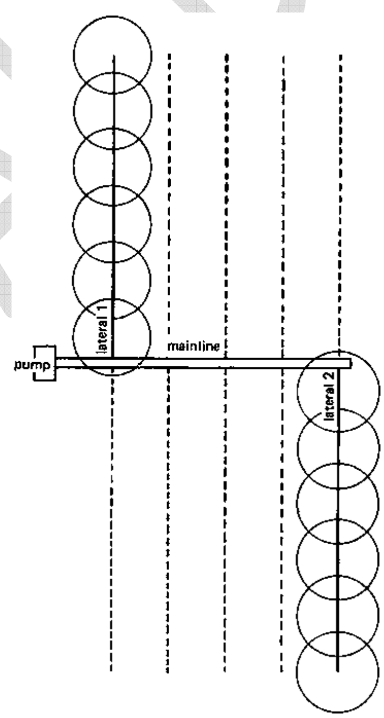


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**Figure 10: Hand-moved sprinkler system using two laterals**

The system consists of lightweight aluminum or plastic pipes which are moved by hand. The rotary sprinklers are usually spaced 9-24 m apart along the lateral which is normally 5-12.5 cm in diameter. The lateral pipe is located in the field until the irrigation is complete. The pump is then switched off and the lateral is disconnected from the mainline and moved to the next location. It is re-assembled and connected to the mainline and the irrigation begins again. The lateral can be moved one to four times a day. It is gradually moved around the field until the whole field is irrigated. This is the simplest of all systems.

Sprinkler and drip irrigation usually have a much higher efficiency than surface methods.

### 1.4 Water Requirements and Cropping Pattern

Crop cultivation in Egypt takes place during three consecutive cropping seasons; the winter, summer and nili (autumn) seasons, depending on the irrigation rotation. Winter season crops (including wheat, barely, beans and clover) are irrigated during the period October – December, and are harvested in May. Following the winter, crops of the summer season are irrigated from April – June and are harvested in October. Those include rice, cotton, maize and sugar cane. The irrigation of Nili season crops takes place during the months of July and August and harvest takes place in November. Crops of the Nili season are mainly similar to summer crops (mainly maize, peanuts, and cotton). Vegetables and fruits are grown all year round, depending on their type.

Wheat and maize are cultivated in all governorates. The season length for wheat, as winter crop, is 155 days. Maize season length is 110 days. Season length for rice is 140 days and cultivated in the all Nile Delta governorates, except El-Monofia governorate. It is cultivated on 15$^{th}$ of May and harvested on 30$^{th}$ of September. Sugarcane is an annual crop planted for sugar industry in 4 governorates, i.e., El-Minia, Suhag, Qena, and Aswan. Spring sugarcane is cultivated on 15$^{th}$ of February and harvested on 14$^{th}$ of February in the following year.

**Table 1: Planting and Harvesting Dates for Wheat And Maize**

| Governorate | Wheat | | Maize | |
|---|---|---|---|---|
| | Planting Date | Harvesting Date | Planting Date | Harvesting Date |
| Nile Delta and Middle Delta | 15 November | 18 April | 15 May | 1 September |
| Upper Egypt | 1 November | 1 April | 1 May | 18 September |

**Table 2: Water requirement for wheat, maize, rice and sugarcane for 17 governorates**

| Governorate | Wheat (mm) | Maize (mm) | Rice (mm) | Sugarcane (mm) |
|---|---|---|---|---|
| **Nile Delta** | | | | |
| Alexandria | 462 | 772 | 1045 | - |
| Demiatte | 495 | 735 | 1018 | - |
| Kafr El-Sheik | 510 | 780 | 1031 | - |
| El-Dakahlia | 519 | 703 | 1116 | - |
| El-Behira | 501 | 728 | 1162 | - |
| El-Gharbia | 497 | 710 | 1104 | - |
| El-Monofia | 521 | 734 | - | - |
| El-Sharkia | 560 | 764 | 1145 | - |
| El-Kalubia | 580 | 802 | 1113 | - |
| **Middle Delta** | | | | |
| Giza | 556 | 871 | - | - |
| Fayoum | 516 | 879 | - | - |
| Beni Swief | 544 | 881 | - | - |
| El-Minia | 531 | 896 | - | 3140 |
| **Upper Egypt** | | | | |
| Assuit | 625 | 895 | - | - |
| Suhag | 546 | 884 | - | 3333 |
| Qena | 654 | 890 | - | 3824 |
| Aswan | 803 | 1090 | - | 4680 |

## 2. Stocktaking of existing and potential solar pumping solutions providers (isolated and hybrid systems) and technical and financial description of the main solutions offered in the Egyptian Market

Solar PV powered water pumps (or photovoltaic pumps, PVP, Solar Pumping) lift water by converting solar energy to electricity which is fed to a pump. A system for agricultural use normally consists of a PV array, controller, pump, storage and an irrigation system. Some parts of the system can be modified, according to the specific demands that the system is set out to meet.

### 2.1 Technical Description of the Main Solution offered in the Egyptian Market

Technical Requirements or Needs to implement PV Irrigation Pump System:

- Power of Sun/ light
- Lack of Capacity
- Land Utilization
- Source of Water (Surface Water or Ground Water
- Technology needs for PV Irrigation solar Pump at the Egyptian Market Materials for PV Installation

### 2.2 Land Ownership: Here in Egypt Land Ownership is divided into Four Categories

*Land tenure in Egypt takes three forms of Fragmentation of Land: (1) Less than 5 Fadden:*

- Fragmentation and dispersal of the agricultural land holding have always had a negative impact on the rate of growth in the agricultural sector. This is evidenced by:
- The difficulty in implementing modern agricultural techniques.
- The loss in the cultivable land due to the fact that a part of it is used for building, irrigation, and drainage purposes, and for passages around and inside small holdings.

**As per our Field Visits (Annex 1), we conclude the following three adequate potentials and proposed solutions:**

a. Farmers who own less than 5 Feddans can form a Conduction Water User Association, that every 25 Feddans share with a panel and distributed the irrigation water according to time schedule.
b. Solar Panel Station Installed to pump water from the distributaries to the irrigate fields.
c. Loan for small farmers to implement and change their Diesel pumps to solar pumps

*Owner More than 5 Feddans:*

PV solar pump model is very effective and efficient for Farms that owned more than 5 Feddans even for individuals or Private Companies. It more economical and cost effectiveness for the land owners and companies.

List of consulted solar pump farms is presented in Annex 2.

*New Venture 1.5 M Fedden (National Project):*

After the change in political conditions that accompanied the 30th of June Revolution, the Government of Egypt (GOE) embarked on applying the policy of horizontal expansion through reclaiming new lands. GOE's comprehensive development plan included reclaiming about one million Feddans distributed in the first phase with a total cost of more than EGP 9,575 million. Most of the project areas will relay on the groundwater. The total numbers of wells that will be used for agricultural propose is 4800 wells.

New ventures system for 1.5 M feddan as mentioned below applies for the graduated youth, small farmers, and 5% of the disables. The total area allocated for these categories amount to 207 thousand Feddans. Under this system, the government is responsible for laying the utilities and basic infrastructure. The cost per feddan is estimated at EGP 185 thousand to be repaid over 49 years.

*The report affirmed allocating a percent of the land for the graduated youth and defined 4 options (systems ) for land distributions)*

Option (1):

Usufruct for 49 years, designed for Arab and Foreign Companies for land reclamation and cultivation. This system allows allocating 5 Feddans per individual in the form of shares in a joint-stock company that provides work and employment opportunities according to qualification and experience. Price per share is determined inclusive of the value of basic facilities implemented by the country, and the life of installments is determined too.

Option (2):

Usufruct for the purpose of acquisition. This system is designed for companies and associations, and imposes the condition of Egyptian contribution by 100% for development purposes. Under this system, lands are offered for acquisition in pieces ranging between 1000 and 10000 Feddans through Egyptian capital companies, and priority shall be given to those companies that present comprehensive agricultural and industrial projects. The property title shall be granted to the company only after the completing the cultivation of the entire area and payment of all dues to the Government according to the schedule set.

Option (3):

Allocation of large areas ranging between 10 and 50 thousand Feddans for Arab or Foreign Companies based on usufruct for 49 years, and granting them exemption from payment for a 3-year period.

Option (4):

Government is issuing a tendering new venture agriculture lands with conditions: 238 Fadden have a water well and can be split (10-23 owners).

## 2.3 Proposal to Prevent Falling in Any of the Mentioned Obstacles

As per our field visit (Annex 1) we conclude the following:

Most of the farmers accept the idea of transform from Diesel Pump to PV Solar Pump but they need financial aid according to the rules and regulation of the donors. The financial guarantees to the bank based on the land ownership or the crop capacity.

## 2.4 Source of Water (Surface Water or Ground Water)

According to the Ministry of Water Resources and Irrigation (2014), the main (almost exclusive) source of water in Egypt is the Nile River. Egypt is unique among other countries in its dependence on water from one deterministic source. The Nile water agreement with Sudan, allocates 55.5 Billion $m^3$/year to Egypt. This amount is guaranteed by the multi-year regulatory capacity provided by the High Aswan Dam (HAD).

Rainfall in Egypt occurs only in winter in the form of scattered showers. The average annual amount of effectively utilized rainfall water is estimated to be 1.3 Billion $m^3$/year. This amount cannot be considered a reliable source of water due to high spatial and temporal variability.

Groundwater exists in Western Desert and Sinai in aquifers that are mostly deep and non-renewable. The total groundwater volume has been estimated at about 40000 Billion $m^3$. However, current abstraction is estimated to be 2.0 Billion $m^3$/year. The main obstacles in utilizing this huge resource are the great depths (up to 1500 m in some areas) of these aquifers and deteriorating water quality at the increasing depths.

Shallow Groundwater in the Nile aquifer cannot be considered a separate source of water. The aquifer is recharged only by seepage losses from the Nile, the irrigation canals and drains and percolation losses from irrigated lands. Hence, its yield must not be added to Egypt's total water resources. Therefore, it is considered as a reservoir in the Nile river system with a huge capacity, but with only 7.5 Billion $m^3$/year rechargeable live storage. The current abstraction from this aquifer is estimated at 6.7 Billion $m^3$ in 2013.

## 2.5 Evolution of Irrigation

Horizontal expansion results in the irrigated areas of Egypt being classified into:

a) The old lands of the Nile Valley and Delta

b) Oases

c) The new lands reclaimed since the High Aswan Dam construction (1970), generally less fertile, on the old lands' fringes, as well as in new locations outside the Nile Valley and Delta such as the western desert.

Irrigation potential is estimated at 10.92 million Feddans. The total area equipped for irrigation was 8.45 million Feddans in 2002; 85% of this area was in the Nile Valley and Delta. In 2010, 8.92 million Feddans are equipped for full control irrigation, including 6.74 million Feddans in the old lands (76%) and 2.17 million Feddans in the Oases and new lands).

## 2.6 Irrigation System in Egypt

Source: compiled and computed from AQUASTAT database- FAO (2016)

The surface irrigation is practiced in the old lands combined with water lifting systems, while pressurized irrigation–sprinkler and localized irrigation–is compulsory by law on the new lands. The latter use a cascade of pumping stations from the main canals to the fields, with a total lift of up to 50 m. Located at the end of the systems, the new lands that are at the fringes of the old lands, are more at risk of water shortage, and pressurized irrigation is more suitable for the mostly sandy soil of those areas. Crops therefore tend to be higher value crops such as tree crops and vegetables in these New Lands (MWRI, 2005).

Freshwater was the only source of irrigation up the 1920-30s, either surface water in the old lands and groundwater in the oases. Reuse of drainage water started after a dry period with a first pumping station constructed in 1928. Shallow groundwater was used outside the oases from the 1950s (El Qausy et al., 2011) and increasingly since then. In 2005, 0.56 million feddans were irrigated by groundwater both in and outside the oases (ARE, 2009).

## 2.7 Soil Productivity

Basic feature of main agro-ecological zones (Soil)

North Costal Areas

- The North Coastal areas of Egypt are composed of two major sub-zones; Northwest Coast and the North Coastal Areas of Sinai.

Soil Types

- Soil types and properties are highly influenced by geomorphic and pedogenic factors.

The main soil units can be summarized as follows:

- Coastal oolitic sand dunes.
- Soils of the lagoon depressions.
- Consolidated dunes.
- Deep sand and clay loam soils.
- Moderate to limited depths of sandy to clay loam. Windblown formations.
- Soils of the alluvial fans and outwash plains over the plateau.
- Water resources are mainly that of rainfall, groundwater resources are limited and usually of low quality especially with respect to varied salinity content.

### 2.7.1 *Types of Soils in Egypt, its Characteristics and Water Resources and is Socio-economic Constraints:*

***<u>North Coastal Areas of Sinai:</u>***

*Physiographic characteristics*

The northern strip to a length of about 5 km from the shore line has a very gentle slope in south I north direction reaching about 20 m ASL in the southern parts. Then a

medium slope develops towards inlands reaching elevations of 90 m ASL. Physiographically North Sinai sub-zone is characterized by the Tina Plain in the east which is formed of

Nile alluvial deposits in the lowest lying areas of Sinai. In the middle is the Bardaeweel lagoon (Shallow Lake). South of Bardaweel extends desert plains with large areas of sand dune belts and sand sheets. The eastern parts of the coastal areas have the highest average rainfall in Egypt. It is dissected by the largest wadi in Sinai, Wadi Al Arish, which emerges from elevated gravelly plains and terraces in the south to a distance of about 20 km till the Mediterranean Sea coast.

*Soil and Water Resources:*

The desert soils of northern Sinai are of three different origins: Aeolian, alluvial and soil formed in situ. The latter is related to land form and is found in the plateau region of Wadi Al-Arish on either calcareous or volcanic parent material.

The majority of alluvial soils were formed under recent climatic conditions. They constitute the present wadi beds and they are characterized by a granulometric differentiation according to flood intensities and sedimentation times. As a consequence, soil in the upstream of the wadis is coarser in texture than the soils further downstream. In the dune area the soils are generally different than in the gravel plain. The dune area is dominated by soils with almost no signs of soil forming processes. Saline soils are found exclusively in the coastal zone. Haplic calciosols are dominant in the desert region in the gravel plains. The Tina plain in the west was formed of alluvial Nile deposits as a natural extension of the old Nile Valley. The soils are heavy textured with high salinity contents due to water logging condition attributed to the near-sea and low lying location.

***Socio-economic Constraints:***

There is little organized marketing of agricultural commodities produced in this zone. Private traders are able to exploit the situation to their advantage. The principal agricultural outputs are lambs, cull stock, fig, and olive oil. There is little structure of the market system and producers tend to sell on an individual basis to a trader. Wool producers receive a poor price because wool is presented for sale in a dirty and upgraded condition and frequently contains sand and foreign matter. There is also an urgent need for small- scale industries to process the rapidly expanding production of fruit, vegetable, and olives for oil. Agriculture development in the governorate Marsa Matrouh has been constrained due to insufficient financial support. The extent of credit for agricultural activities remains minimal.

***Nile Valley and the Reclaimed Desert Fringes:***

*Soil and Water Resources*

Soils vary but include the fertile deep alluvial soils of the old Nile Valley, soils of the river terraces at different reliefs which are deep soils with gravelly and reddish sub-soils in addition to the soils of the fringes including desert calcareous soils of varied textures and non- calcareous soils characterized with low soil fertility and inferior soil physical, chemical and biological properties.

***Inland Sinai and the Eastern Desert***

It occupies the central portion of El Tieh table land. To the west, it is limited by the upstream portion of Al Arish and its tributaries. This excavation stretches in a NW-SE direction for about 40 km attaining about 15 Km width at bir El Malha area. Due to this depression both Egma and El Tieh table lands are completely separated. The surface of this table lands is intensively dissected with drainage lines, flow towards north, and joining together into Al Arish. The eastern desert is comprised of the following landforms.

- The high Rocky Mountains: Generally, the surface of the Eastern desert is very rugged and rises in some places to more than 2000 m ASL especially in the southern areas.
- The desert floor: it is covered with countless sounded highly- polished pebbles of brown flint or white quartz, materials brought down by ancient streams and spread out near the former shore-line.
- The drainage channels: They are intensely dissected by valleys and ravines and all their drainage are external. Most of the drainage lines run along major fault lines, and it is noticeable that while the eastward drainage lines run to the Red Sea by numerous independent wadis, the westward drainage lines run to the Nile Valley. Coastal mountains form the water divide.

***Western Desert, Oases and Southern Remote Areas***

*Soil Resources*

The soils have been classified as weakly developed Red Desert soils which have higher chrome than typical Red Desert soils and they have a very thin or no A-horizon. The formation of these soils is from a number of parent materials, indicating that the hot dry climate was the main soil forming factor that is responsible for the characteristics of these soils as Red Desert soils. The soils are formed of sand and are calcareous in nature.

*Socio-economic Constraints*

The present population and communities are scattered with low educational background. Although skills and handcrafts are available, however, technological skills to address the needs of development activities are rare. There are definite needs to create incentives to reverse the present migration trends toward urban centers of the Nile Valley in addition to the attraction of human resources to migrate to the newly developed areas in the Western Desert.

*Market – Distribution Channels:*

Egyptian Opportunity to open new market for the PV Irrigation System:

Egypt's progress in implementing solar projects has been limited though it has very attractive sites for solar energy that could be used to generate electricity directly through photovoltaic (PV) technology. However, Egypt has little local capacity in the PV technology and it does not have much capacity to locally produce the components of solar irrigated systems. Conceptually the system can be divided into three parts: **inverters, PV** and **pumps**. Normally these systems are manufactured by big industrial companies with long-term experience in the field.

A number of small companies that are involved in supplying solar water pump systems with different brands that are manufactured from different countries. Below show different key components (inverters, PV and pumps) and their suppliers.

Development of local manufacturing capacity in the renewable energy industry has been supported by the government of Egypt. Table 1, Table 2 and Table 3 display a list of inventors, PV and pump supplier in the Egyptian Market, respectively.

**Table 3: List of Inverters in the Solar Egyptian market**

| Item | Inverter Supplier | Manufacturer |
|---|---|---|
| 1 | Invt | China |
| 2 | POWTRAN | China |
| 3 | ABB | Switzerland |
| 4 | VEICHI | China |
| 5 | Kostal | German |
| 6 | Effekta | German |
| 7 | Socomec | France |
| 8 | MW Mean Well | Taiwan |
| 9 | Huawei | China |
| 10 | Ingeteam | Spain |
| 11 | Schneider Electric | France |
| 12 | Danfoss | Denmark |
| 13 | Growatt | China |

**Table 4: List of PV in the Egyptian Market**

| Item | PV Supplier | Manufacturer |
|---|---|---|
| 1 | SUNTECH | China |
| 2 | GTS – CNBM | China |
| 3 | Fortune CP | Japan |
| 4 | Trina Solar | China |
| 5 | ReneSola | China |
| 6 | JINKO Solar | China |
| 7 | ALEO | German |
| 8 | EMMVEE | India |
| 9 | AxSun Solar | German |
| 10 | Resun Solar | China |
| 11 | CSG PVTeck | China |
| 12 | PTP Energy Solutions | China |

**Table 5: List of Pumps in the Egyptian Market**

| Item | Pump Supplier | Manufacturer |
|---|---|---|
| 1 | Shakti | India |
| 2 | Speroni | Italy |
| 3 | LORENTZ | German |
| 4 | KPS | Turkey |
| 5 | Varuna | India |
| 7 | Grundfos | Denmark |
| 8 | Alfa Laval | Sweden |
| 9 | Franklin Electric | United State |
| 10 | ALLWEILER-FARID | German |
| 11 | Farrouk and Awad | N.D |
| 12 | Bharat | India |
| 13 | Ahmed Daoud | Egypt |
| 14 | Calpeda | Italy |
| 15 | KSP | Germany |

N.D: Not Detected

Development of local manufacturing capacity in the renewable energy industry has been supported by the government of Egypt:

*Proposal*

The plain environment, in recent years, the local modern irrigation facilities were established with drip irrigation, sprinkler irrigation and micro-jet irrigation pipe network. With the promotion of network coverage, part of the regional power shortage, photovoltaic (PVP) solar pumping system is applied in these areas, perfect to solve such problems.

Because it's located in the plain area, the irrigation pipe need certain pressure at work, high-level reservoir was built beside the well, at the same time provide natural pressure in the storage of water. Solar water pump system will pump water from well into the reservoir, fully automatic operation, supplement water day after day.

The Component of Solar Pumps consist of the **Support structure and tracking mechanism, Foundations (array and pump, Electrical interconnections, Earthing kit, Plumbing**., R**eservoirs to store the excess water, Technology and updates**.

In order to ensure the safety and convenient management of photovoltaic (PVP) lift water equipment, the construction unit built open platform on the top of the reservoir, the solar panels were installed on the top, the control section was arranged in the pump room, to prevent vandalism and theft, protection of the normal work of solar pumping system, prolong service life.

Batteries are a key part of (PVP) solar systems in most applications, but are rarely used in stand-alone solar pumping systems. The reason why batteries are not preferred is because they add extra cost to the system for about 50%, while it have a shortage life batteries Also batteries typically have a total efficiency of 0.5 (charging and discharging efficiency 0.7), thus finally supplied power is only half of what is feeded into the battery. In addition batteries need cooling to be more efficient. Usage of

battery makes sense only if device to be operated by solar power has to work in the night which is often not the case with pumping systems

This project adopts the multiple sets of same power solar water pump system, single set of system power 10 kW, head 20 meters, daily water output 250 cubic meters, meet the demand of irrigation. At the same time equipped with the same model spare parts and on-site staff training. Through telephone technical support after failure occur, can be done to solve the trouble for several hours.

Solar water pumping system in normal use life of 15-20 years (replacement of wearing parts), full power to rely on solar energy without diesel fuel and power costs, farmers benefit from no economic burden. At the same time, zero carbon emissions and zero pollution to protect the earth's environment.

*Power of Sun/ Sun Intensity/light*

Egypt receives annually 2,400 hrs of solar operation with high intensity of solar radiation equivalent to 2,600 $kWh/m^2$ Egypt has an average direct normal solar radiation of 2000-3200 kWh per sq. meter per year from the north to the south. The sunshine duration reaches between 9 -11 hour/day from north to south with very few clouds day. Egypt is shining most of the year (365 day/year)

### 2.8 Mandatory Technology

Mandatory Technology are utilized for Solar Pumping Irrigations at the Egyptian Market:

According to our field visits Annex (1) there were are two systems for irrigation in the New Land as mentioned below:

- A solar system produces electricity to drive a submersible motor pump, which pumps water into an elevated pond (eg. Bahariya Oasis and El Minya, Annex 1). The pond serves as an energy store and supplies the pressure needed for the irrigation system. The stored water can bridge periods of low insolation and supplies the pressure needed for the irrigation system.
- The PVP (Solar Pumps) inject the water directly into the irrigation system (eg. Wadi El Natrun). This can reduce the initial capital outlay by as much as 35%. However, due to daily fluctuations of global radiation, these systems operate at variable system pressures and water flows.

Old Land:

- The PV-irrigation systems depend on the surface pumps which drive water directly from the waterway to the farm land (eg. Damnhour, Annex 1).
- The PV-irrigation systems depend on the surface pumps, which drive water directly from the waterway earthen pond (eg. Ismailia, Annex 1) The pond serves as an energy store and supplies the pressure needed for the irrigation system. Also, the stored water within the pond is usually injected with chicken manure to be used as fertilizer. The irrigation in this system is regulated by manual valves.

**Lack of Capacity**

The interview survey found that there are positive impacts of solar pumping on local community, namely the creation of new small businesses and jobs, agricultural and other productive activities, and household income. The impact of the solar pumping on the local communities and their responses are shown as the following:

- Clear guidelines are obligatory to achieve utilizing Solar pumping system. (Road Map)
- We need to consider the best way to provide solar pumps according to crop patterns, water resources and water requirements.
- There is lack of private sector participation in small irrigated solar energy development.
- There is lack of joint venture (public and private sector partnership).
- There is lack of access to network and share of best practices and information dissemination through public consultations, workshops, forums and conferences

Proposal according to our 16 field trips to farms and discussion with farmers:

a. Protect the location and panels by establishing iron fence around the solar energy plants in order to avoid the disturbances from both children and traffic.

b. Buffer zone should be established around the solar energy plants (about 20 to 50 m) in order to allow the light and solar radiation for passing through the solar cells.

c. Clear guidelines are needed. (Solar Pump, Environmental Concerning, generating electricity, maintenance and operation and laws… etc.)

**Education**

Impact of the pattern of the holding on education, the Egyptian countryside suffers from a high level of illiteracy In the old Land: the percentage of illiterate or semi-literate holders of agricultural land is greater than 74%. This has a negative impact on the rate of growth of agriculture since these holders are not in a position to appreciate the concept of technology transfer in their crop land. In the New Land: the percentage of illiterate or semi-literate holders of agricultural land is greater than 70%. They may have a negative impact on the rate of growth of agriculture. However, they are holding about 22% of the total agricultural land. The percentage of the educated holders is 30% but they are holding 78% of the total agricultural land and they may appreciate the concept of technology transfer in their crop land.

### 2.9 Materials Required for Solar Pumps (PVP) Installation

The whole system of solar pumping includes the panels, support structure with tracking mechanism, electronic parts for regulation, cables, pipes and the pump itself. Not all the mentioned components are available to the Egyptian Market. At the components are imported suppliers as follows as follows:

a **Solar panels or modules**: Solar panels are the main components used for driving the solar pump. Several solar panels connected together in arrays

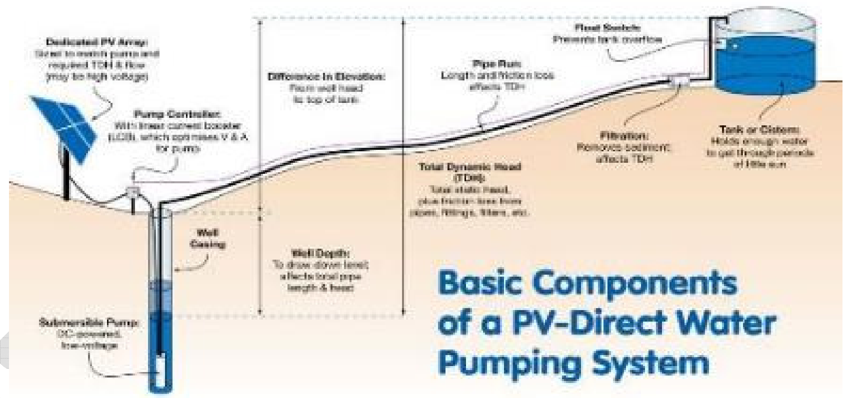
produce DC electricity, interconnections are made using series or parallel combinations to achieve desired voltage and power for the pump.

b **Solar pump**: Centrifugal or submersible pumps are connected directly to the solar array using DC power produced by the solar panels. Solar pumps are available in several capacities depending upon the requirement of water. (Ground Water- and for surface water we need surface lifting pump to get water directly from canals)

c. **Inverters:** Inverters are an important part of any solar installation, they are brains of the system. The main job is to convert DC power produced by the solar array into usable AC power. Inverters can also provide diagnostic information to help O&M crews identify and fix system issues.

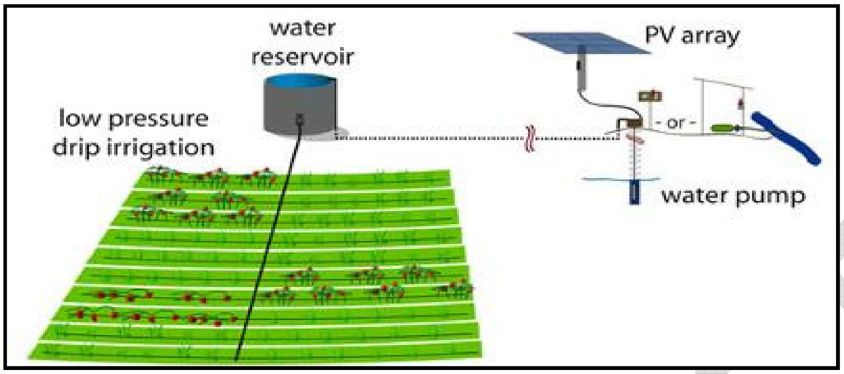
d. **Batteries to store the excess electrical energy:** Batteries are used to store the solar energy in form of DC electrical energy to be used in water pumping during the absence of the sun.

e. **Storage tanks to store water:** Ground storage tanks or high level storage tanks are required (transfer to the locally manufactured)



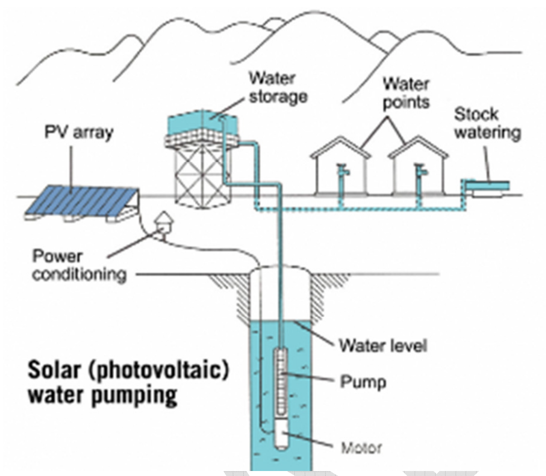

f. Monitoring system for output: not obligatory but important for remote plants

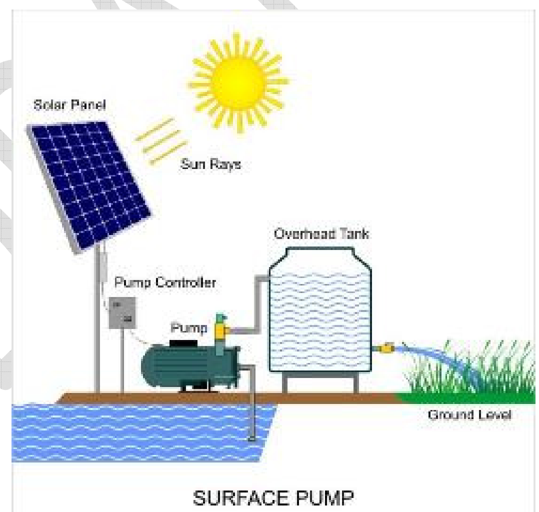
**a) Direct Water Pumping System**




**b) Low Pressure drip irrigation**

**Figure 11: PVP System Components**




**d)**

**Surface Pump**

**Figure 12: PVP System Components**

The below mentioned components are available and manufactured in the Egyptian Market:

a **Support structure and tracking mechanism**: Support structure provides stability to the mounted solar panels and protects them from theft or natural calamities. To obtain maximum output of water, a manual tracking device is fixed to the support structure. Tracking increases the output of water by allowing the panels to face the sun as it moves across the sky. (Manufactured in Egypt)

b **Foundations (array and pump):** Foundations are provided for support structures and pump.

c **Electrical interconnections**: A set of cables of appropriate size, junction boxes, connectors and switches are provided along with the installation.

d **Earthing kit**: Earthing kit is provided for safety in case of lightning or short circuit.

e **Plumbing:** Pipes and fittings required to connect the pump come as part of the installation.

f. **Reservoirs to store the excess water:** To overcome the community's water needs in nights and cloudy days, it is advantageous to store enough water using a higher sited reservoir during the sunshine time. Where there is not solar radiation, it will be distributed under gravity force in the time. Storage Earthen Ponds used to store water for Irrigation Pump

i- **Technology and updates** are essential for PV Irrigation solar Pump at the Egyptian Market. There is a lack of skilled technicians to install and repair the PV solar panels.

According to our 16 site visits (Annex 1) please note that there are four different system configurations have been employed within the scope of the solar pump (PVP)-irrigation systems:

- **In the first case**, a solar generator produces electricity to drive a submersible motor pump, which pumps water into an elevated pond (eg. Bahariya Oasis and El Minya). The pond serves as an energy store and supplies the pressure needed for the irrigation system. The stored water can bridge periods of low insolation and supplies the pressure needed for the irrigation system. Pilot plants equipped with a water tank operate at considerably low system pressures, compared to conventional diesel or petrol pumps. This presumes, of course, that all components of the irrigation system have been designed for such low pressures. PVP elevated tank irrigation systems operate at constant pressure of approximately depending on the height of the water tank and with a rather constant water flow. Irrigation is regulated by hand valves.

- **In the second case**, the Solar Pumping injects the water directly into the irrigation system (eg. Wadi El Natrun). This can reduce 35% of the initial capital outlay. However, due to daily fluctuations of global radiation, these systems operate at variable system pressures and water flows.

- **In the third case,** the Solar Pumping-irrigation systems depend on the surface pumps which drive water directly from the waterway to the farm land (eg. Damnhour). The operation of the existing irrigation system is based on rotational water deliveries to individual branch canal. The main feeder canal flow continuously and the off taking branch canals head regulators are opened according to a rotation schedule. At a particular lifting point, different farmers take turns to irrigate using the PV-lifting pumps. In some cases, farmers with fragmented holdings agricultural farms may use a single pump which is moved between their different plots. The farmers can rent this lifting pump that costs 7 Egyptian pounds (LE)/hour. In addition, there is Water Users Associations (Five members for each lifting pump). According to the finding of the field

visits (Annex 1 and 2), these associations play important roles for improving crop yield and values of land/waters, reducing hours per irrigation, and participating with higher-level organization of the branch canal and cooperation with the district engineer.

- **In the fourth case**, the PV-irrigation systems depend on the surface pumps which drive water directly from the waterway earthen pond (eg. Ismailia) as shown in Figure (29). The pond serves as an energy store and supplies the pressure needed for the irrigation system. Also, the stored water within the pond is usually injected with chicken manure to be used as fertilizer. The irrigation in this system is regulated by hand valves.

**Old Land**: According to our 16 site visits (Annex 1) we recognized that it is very difficult to integrate the surface and ground irrigation system as of the (i) Land is fragmented, (ii) Nocturnal irrigation, (iii)) farmers mindset are reluctant to adapt to new technology and they cannot be changed , (iv) high cost of the Installation of PV system, (v) Farmers are literate they do not understand technology – unskilled labors (not aware of all technical aspects i.e. lifting pumps) , (vi) Restrictions of Law, (vii) Poverty of Farmers as they are not able to purchase and employ PVP irrigation pump system .

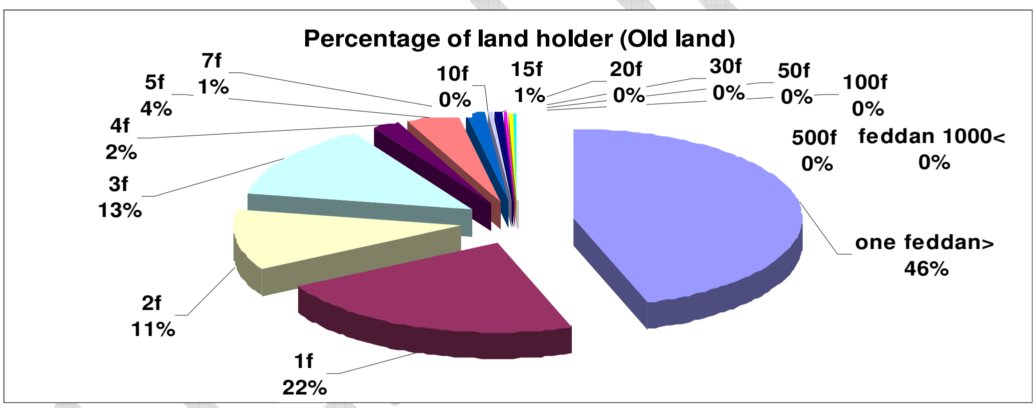



**Figure 13: Percentage of Landholder area in the Old Land (f=Feddan)**

Source: compiled and computed from Agricultural census results - Directorate General Agricultural Census (2009-2010)

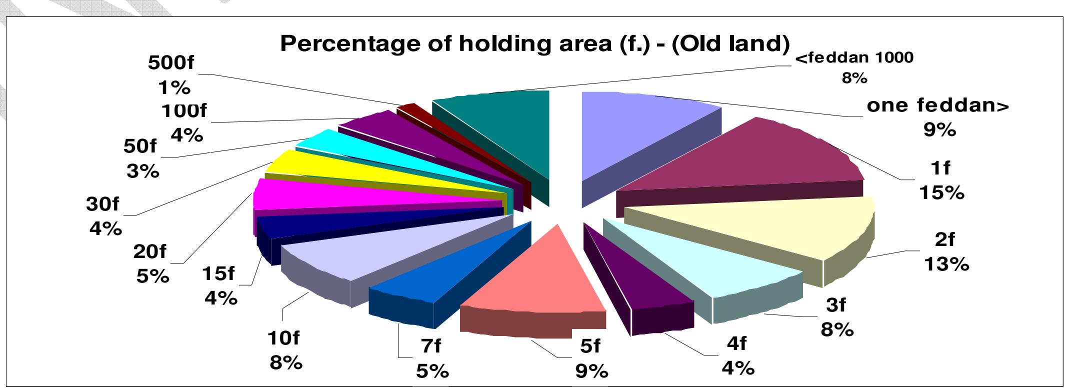


**Figure 14: Percentage of Landholder Area in the Old Land**

Source: compiled and computed from Agricultural census results - Directorate General Agricultural Census (2009-2010)

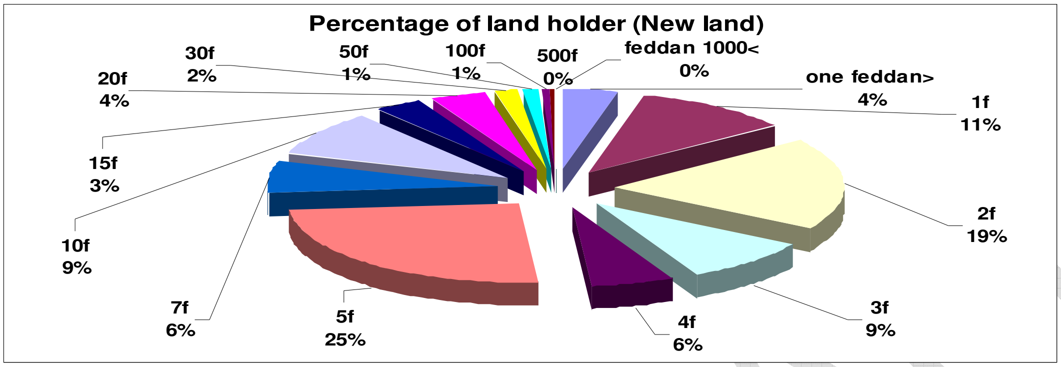



**Figure 15: Percentage of Landholder in the New Land**

Source: compiled and computed from Agricultural census results – Directorate General Agricultural Census (2009-2010)

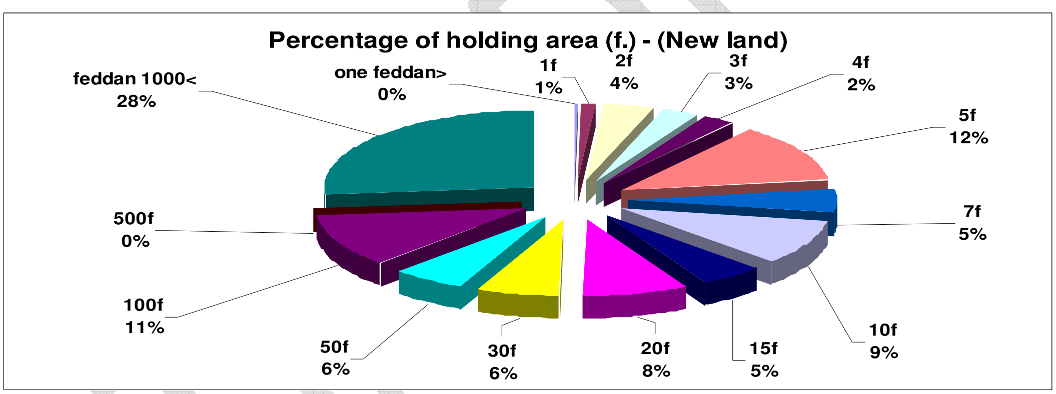



**Figure 16: Percentage of Landholder Area in the New Land (f=Feddan)**

Source: compiled and computed from Agricultural census results – Directorate General Agricultural Census (2009-2010)

## 2.10 Advantages of Solar Pumping

1. One major advantage of solar pumps is that they do not require batteries, which are expensive and need a lot of maintenance. In another word, we can say that there is no energy cost to pump the water. The maintenance of the solar pump (PVP) irrigation system is restricted to regular cleaning of the solar modules.
2. Only small amounts of energy can be stored (in some cases, less than 1 or 2 kWh, depending on the amount of batteries and their capacity). Storage batteries raise the initial cost of the total system by 40% higher. The batteries need to be replaced at least every 5 years.
3. For those few farms, whom installed batteries, during night the house are light using the solar energy saved in batteries and also they can utilize the batteries in nocturnal irrigation (irrigation at night) .

4. The power source for sunshine for solar pump depends on the weather conditions for a given place. Weather in Egypt always sunny this is an advantage for solar panel to generate electricity.
5. Depending on the water quality, the only moving part of the system, the submersible motor pump, has to be checked every 3 to 5 years.
6. Drip irrigation in New Land saves a considerable amount of water compared to other irrigation techniques. Furthermore, it has a rather low operating pressure. Both features reduce the energy demand and make drip irrigation particularly suitable for photovoltaic pumping systems. Unlike other irrigating processes, drip irrigation is amenable to a continuous supply of water, so the pump can run incessantly through the entire growing season.
7. PVP must be designed for the maximum water requirement.
8. The difference between the actual demand and the supply of water detracts from the system's overall degree of utilization should be required..
9. The degree of utilization of solar pumping systems.is depending on water requirements fluctuate
10. Crop rotation patterns and high value crops are suitedto irrigation by a PVP system.
11. The photovoltaic panels should be put on rooftops to protect them from the criminals and allow the light and solar radiation for passing through the solar cells).
12. Solar pump can be at rural locations with no access to grid power.
13. High rates of system utilization are necessary to achieve economic viability of PVP irrigation systems. Therefore, PVP systems are limited to irrigate permanent crops and continuous crop rotation in arid climates. High value-added cash crops like fruits, vegetables and spices should be given preference to recoup the high initial investment.
14. PVP irrigation systems require a careful planning of the crop schedule and are more demanding of user skills.
15. Solar irrigation systems are bound to gain importance in the future, primarily by virtue of their low environmental impact, high reliability and lack of dependence on fossil energy sources.
16. A single axis vertical solar tracker has better efficiency and generates more electricity that the fixed form. Power production increases by 20 – 25%.

## 2.11 Financial Proposals in the Egyptian and World Market

Solar Pump for agricultural irrigation value chain finance is concerned with the flows of funds and within a value chain to meet the needs of chain actors for finance, to secure sales, to buy inputs or produce, or to improve efficiency.

Examining the potential for value chain finance involves a holistic approach to analyze the chain, those working in it, and their inter-linkages. These linkages allow financing to flow through the chain. For example, inputs can be provided to farmers and the cost can be repaid directly when the product is delivered, without need for farmers taking a loan from a bank or similar institution.

This is common under contracting for the solar pumping system arrangements. Types of value chain finance include product financing through trader and input supplier credit or credit supplied by a marketing company or a lead firm.

Other trade finance instruments include receivables financing where the bank

advances funds against an assignment of future receivables from the buyer (Crop Capacity or Land ownership) , and factoring in which a business sells its accounts receivable at a discount. Also falling under value chain finance are asset collateralization, such as on the basis of warehouse receipts, and risk mitigation, such as forward contracting, futures and insurance.

## 2.12 Investment Capacity and Strong Financing Tools

**Encourage financial institutions to implement low interest loans and grants.** Financial services provided are also crucial to develop solar pump irrigation system production capacities and Renewal Energy components manufacturing facilities. Interviews have revealed that financial actors – especially local commercial banks – have limited knowledge of the viability of renewable energy projects and of the potential for investment in industrial assets to manufacture Renewable Energy components locally.

Building the farmers financing capacity is necessary to help Small and Medium Enterprises (SMEs) extend their production assets and meet the volume and quality standards required in high-voltage Renewable Energy projects, especially when the ambition is to export part of these components on regional and international markets.

Capacity building mechanisms will depend on country-specific conditions. For instance; the initiatives led by the National Agency for Energy Conservation (ANME) through the PROSOL-Elec in Tunisia are an interesting example of incentive measures, including the granting of an investment premium through a national fund or the possibility to subscribe to bank loans with favorable terms on the credit line for energy management.

Implement investment support mechanisms. In order to attract investors to the sector, investment support mechanisms are essential to overcome existing financing barriers and increase the financial feasibility of renewable energy projects. These mechanisms may include regulatory and incentive measures likely to direct investment towards renewable energy (for the development of both projects and industrial manufacturing assets).

Targeted interventions could help maximize the leverage of additional investments by unlocking existing barriers as. financing, . This could be achieved through lending risk mitigation, loan softening programs, project debt financing or grants for project development costs.

### Investment

*Assessing the efficiency of national and agricultural investments*

Investments contribute to creating new employment opportunities and achieving high rates of growth. Therefore, the success of agricultural development policy depends on the size of available investments and efficiency of utilization. Hassan, et al (2016) assessed the investment efficiency by using the following group of indicators that are presented in Table below:

### Investment on agriculture sector

*Impact of agricultural investment on agricultural sector*

Table and Figures below show that average investments in Egypt amounted to EGP 147.85 Billion for the period 2000-2013. It is clear that the oil sector absorbed the largest share of this investment, estimated at 16.33%, followed by the transportation sector (11.4%), the electricity sector (7.07%), and finally came the agricultural sector (5.14%).

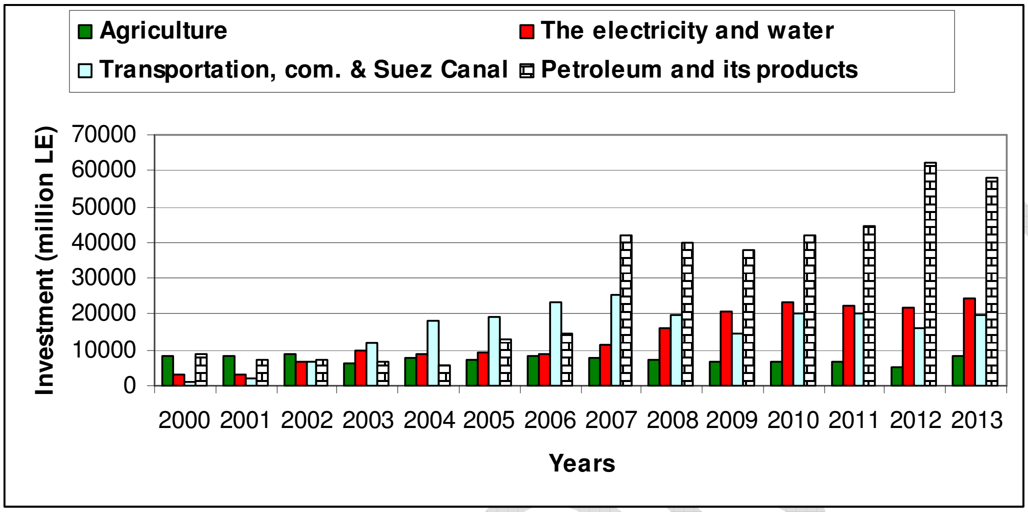



**Figure 17: Investments in Egypt**

Source: compiled and computed from Agricultural census results - Directorate General Agricultural Census (2009-2010)

Table and Figures below indicate that total investment, gross domestic product, agricultural employment, total exports and imports, and deficit in the balance of trade increased to EGP 160 billion, EGP 12,223.2 billion, EGP 2.157 million workers, EGP 181.2 billion, EGP 405.4 billion, and EGP 224.2 billion in 2013, respectively, which are 169.1%, 386.6%, 42.6%, 1098.4%, 801.2%, and 657.5% higher compared to 2000. The Table and Figures also indicate that agricultural exports and imports accounted for 10.05% and 10.37% of the total exports and imports. It is also clear that agricultural investments accounted for 5.14% of the total investments, agricultural loans accounted for 17.04% of the total loans, and agricultural savings accounted for 6.05% of the total savings. Moreover, the number of workers in the agricultural sector was 5,065 in year 2000 and increased to a number of 7,222 in year 2013.

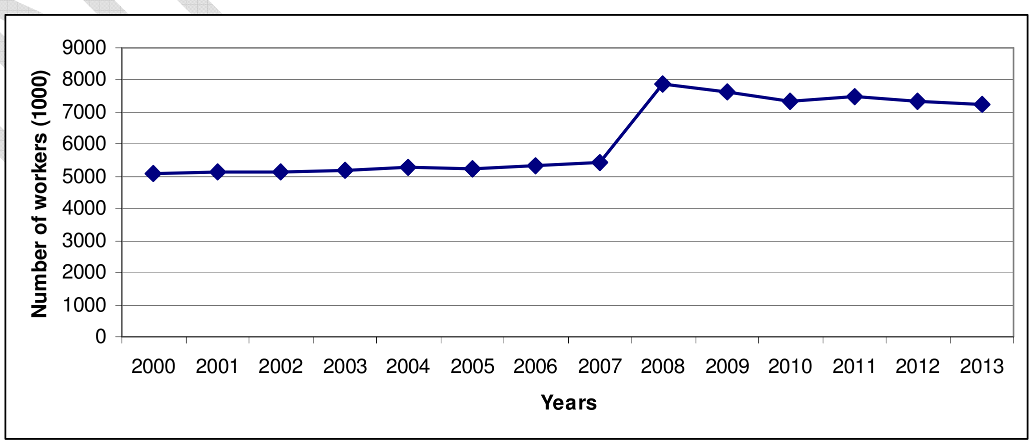


**Figure 18: Number of Workers in the Agricultural Sector**

Source: compiled and computed from Agricultural census results - Directorate General Agricultural Census (2009-2010)

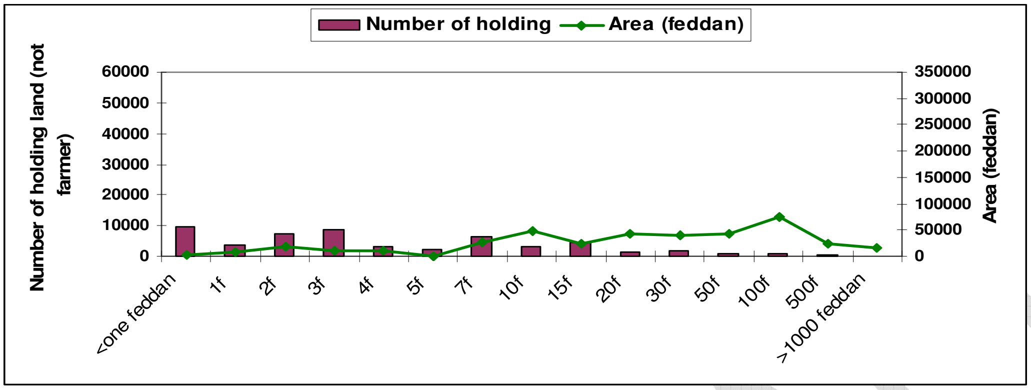



**Figure 19: Number and Area of Land Holder by Categories of Job (Not Farmer) In the New Land**

Source: compiled and computed from Agricultural census results - Directorate General Agricultural Census (2009-2010)

*Investment and developing the agricultural sector*

Plant production activity depends on cultivating old and new lands. And despite old lands are characterized by high production value and net revenue, in addition to low value of inputs compared to new lands, it is not economically feasible to allocate investments to old lands due to its limited area and difficulty to add new areas to the currently available ones. However, increasing production from old lands depends on vertical expansion, which can be achieved by using high yielding varieties and modern farming technologies. As regards production from new lands, horizontal expansion requires reclaiming new areas, in addition to adopting good agricultural practices that depend on transfer of the know-how technology.

**Funds and Loans**:

There are policies and Schemes are funded by International bodies like World Bank, Egypt SEFF, JICA, ODA – Minor Irrigation Project, Water Resources Dept.

**Egypt SEFF , Rules and Regulations : Assisted Project**

- Loan amount: Up to USD 5 million.
- No commission.
- Interest rate: 3% + Central Bank of Egypt's lending rate for EGP with a minimum of 12%; 4% above 6 months Libor for USD; 4% above 6 months Euribor for Euro.
- Investment incentive grant: 10% or 15% of loan amount (excluding customs and taxes).
- Technical assistance: Loan application preparation and documentation

| Fact | Details |
|---|---|
| Maximum loan amount | Up to 100% of the investment cost with a maximum of USD 5 million for projects up to USD 10 million. |
| Loan currency | EGP, USD or EUR |
| Interest rate | 3% + Central Bank of Egypt's lending rate for EGP with a minimum of 12%; 4% above 6 months Libor for USD; 4% above 6 months Euribor for Euro. |
| Repayment Period | Up to 5 years (including a grace period up to 1 year). |
| Commission | No commission |
| Investment incentive grant | 10 or 15% off investment cost or disbursed loan amount whichever is lower excluding custom duties and taxes (incentive % depends on technical elements of the project). |
| Free technical assistance | Available (assistance in application and documentation |

To finance the solar pumping irrigation system please find the following proposal :

Land Fragmentation:  Less than 5 Feddan

Option (1):

Farmers owned less than 5 Feddan: Farmers who own lands which are fragmented the cost of the PV Solar Irrigation System will be very high and no cost effective. If Small Farmers need financial aid to change to PV `Solar Pumping Irrigation they have to follow the rules and regulation either of the Banks, Agriculture Bank of Egypt agencies and the NGO's.

Option (2):

Solar system finance is shared by the owner of the farm (20 persons). The (20) farmers can conduct an association

Option (3):

Selling crops in advance can cover the initial cost.

Option (4): Private Sector

**Return of Investment** (R.O.I).

However, the situation will be different if the water is not free. In new lands, the irrigation method is either sprinkler or dripper that consumed less water than flood method. Water productivity indicator in physical unit can be used only to compare the productivity of water in old and new lands for the same crop.

**Table 6 :Crop Water Productivity for Main Winter Field Crops in Old and New Lands under Different Irrigation Methods**

| Crop | Wheat | | Long Clover | | Faba bean | | Sugar beat | |
|---|---|---|---|---|---|---|---|---|
| | Old land | New land | Old land | New land | Old land | New land | Old land | New land |
| Irrigation Method | Flood | Sprinkler | Flood | Sprinkler | Flood | Drip | Flood | Drip |
| Water Requirement ($m^3$/feddan) | 1,677 | 1,751 | 2,773 | 2,608 | 1,371 | 1,008 | 2,007 | 1,415 |
| Total Production (Ton/feddan) | 3.41 | 2.48 | 30 | 26 | 1.4 | 1.55 | 25 | 19 |
| Net Return (L.E/feddan) | 5,850 | 3,054 | 1,056 | 950 | 1,000 | 1,732 | 779 | 779 |
| Water Productivity Indicators | | | | | | | | |
| water Unit Productivity ($Kg/m^3$) | 1.97 | 1.37 | 10.82 | 9.97 | 1.02 | 1.54 | 12.46 | 13.43 |
| Water Unit Net Return ($L.E/m^3$) | 3.49 | 1.74 | 0.38 | 0.36 | 0.73 | 1.72 | 0.39 | 0.55 |

Source: - Calculated from the survey data of agricultural year 2007/2008.
- Central agency for Public Mobilization and Statistics, Bulletin of irrigation and water requirement, 2004.

# 3. Analysis of the main opportunities, drivers, gaps and barriers for a consequential deployment of solar pumping systems in the Egyptian Agricultural and Irrigation for the river based and ground water irrigation respectively.

## 3.1 Strengths', Weaknesses, Opportunities and Threats of Solar Powered Water Pumps

Successful application of any water pump (whether powered by human or animal muscle, gravity, fossil fuels or renewable sources) requires a balanced match between the demand for water and supply of the resource chosen to run the pump. In the case of PVP, solar energy is plentiful available in many dry areas of the world. However, due to cloudy periods causing disruption in the water supply, the installation of water storage is advisable.

Nonetheless, PVP are able to provide an economic and ecologic alternative to small to medium sized Diesel pumps, in particular as PV-module prices are falling. Despite higher upfront investment costs (compared to Diesel pumps), economic feasibility is met due to the significantly lower costs. The following table lists the strengths, weaknesses, opportunities and threats of PVP.

The key findings of Egypt's renewable energy manufacturing potential are displayed in the SWOT analysis below:



| Strengths | Weaknesses |
|---|---|
| **Industry Maturity:**<br>▪ Broad based and competent companies<br>▪ No fuel costs nor volatility of fuel prices<br>▪ Electricity is available around the clock, eliminating the inconvenience caused when the other types of fuels run out during use.<br>▪ A well-designed solar system requires little maintenance beyond cleaning of the panels once a week | **Industry Maturity:**<br>▪ Market volume in Egypt and surrounding countries is not large enough<br>▪ Local productivity level lower compared to Europe<br>▪ To outstay political decisions, industry rely only on visible market.<br>▪ Less established in the Egyptian markets |
| **Technological skills :**<br>▪ Enough and well educated labor available | |
| **Economic and regulatory Assets:**<br>▪ Government announced large investments into distribution and transmission grid<br>▪ Government and institution are willing to drive public and private projects.<br>▪ Foreign financial institutions are interested in Egypt. | **Economic and regulatory Assets:**<br>▪ Local interest rates of 9 – 11 % are quite high<br>▪ Lower interest to encourage farmers<br>▪ Loans often bound to foreign currency increases exchange risk.<br>▪ Local manufacturer with high import values may have disadvantages in public tenders due to customs duties already paid on imports |
| **PVP Irrigation**<br>▪ Reducing of production cost<br>▪ Easy installation<br>▪ A safe, continuous source of energy, especially compared fossil oil which are both less environmentally friendly and have more associated waste by products, Green Energy<br>▪ A continuous, clean source of electricity that will be operated,<br>▪ Since there is no fuel required for the pump like electricity or diesel, the operating cost is minimal. | **PVP Irrigation**<br>▪ Relatively high upfront investment costs<br>▪ Water storage is required for cloudy periods<br>▪ Batteries are required for cloudy periods<br>▪ Pump Efficiency<br>▪ No Spare parts in local market<br>▪ Unstable in the economy<br>▪ Nonprofessional technical labors<br>▪ Fragment lands<br>▪ Crop pattern |

| | |
|---|---|
| ▪ It gives maximum water output when it is most needed i.e. in hot and dry months. | ▪ Nocturnal Irrigation especially for Old Land. This means that we have to change the irrigation system completely as the farmer irrigate that land at night. If the farmer utilized the storage system in the PV irrigation system this means that the cost will be increased approximately 40%. Storage of water cannot be useful as the water level is higher than the irrigated agricultural land in order to be irrigated by gravity.<br>• Poverty of the Farmers |
| **Opportunities**<br><br>➢ **Finance**<br>▪ Foreign financial institutions willing to provide loans in local currency.<br>▪ Purchasing the agriculture land of a high price<br><br>➢ **Competitiveness**<br>▪ Local manufacturing can decrease LCOE<br>▪ Increase export to neighbor countries<br>▪ Falling PV-module prices improve the economic competitiveness of PVP<br><br>➢ **Technology**<br>▪ Companies open for cooperation, joint venture, know how transfer<br><br>➢ **Regulations**<br>▪ Law under preparation that would allow for use of state owned land<br>▪ Decreasing of subsidies on electricity to zero in the next y years.<br>▪ Define/establish local certification criteria, limits or local manufacturing<br><br>➢ **Socio-economic impacts**<br>▪ Creating Job Opportunities to skilled and unskilled laborers<br>▪ Increased harvest<br>▪ Potential micro-market for excess water<br>▪ Electricity can be used for other purposes in the off-season with relative ease<br><br>➢ **Environment Impacts**<br>▪ $CO_2$ reductions compared to Diesel-powered pumps - Clean Environment better health | **Threats**<br><br>➢ **Finance**<br>▪ Foreign finance institutions not providing enough equity.<br><br>➢ **Competitiveness**<br>▪ Local manufacturing can increase LCOE<br>▪ Public tender qualification criteria too restrictive for local players.<br>▪ Limited on grid capacity & long transmission distances delays market size.<br>▪ Private market not able to absorb capacities<br><br>➢ **Technology**<br>▪ Faulty installation (direction of panels, wiring etc.)<br>▪ Unskilled technicians for repairing PVP Systems , in which they are not available in the Egyptian Market<br><br>➢ **Regulations**<br>▪ Law under preparation that would allow for use of state owned land<br>▪ Decreasing of subsidies on electricity to zero in the next y years.<br>▪ Define/establish local certification criteria, limits or local manufacturing<br><br>➢ **Socio-economic impacts**<br>• Lack of maintenance (clean panels, yearly checks on the pump and power controller) will lead to reduced output<br>•<br>• Overuse of water resource<br>• Protection from vandalism (panels etc.)<br>• Theft of equipment (panels etc…) |

One major risk that may undermine the development of this sector would be that the government sets out a too ambitious threshold for requested local manufacturing share for solar PV projects. As component manufacturing of PV systems needs a huge and stable market potential to justify the investment in new facilities and production lines, it is recommended to ramp-up this local manufacturing share diligently.

Ultimately, the choice of the right pumping technology depends on the local circumstances, in particular concerning the available resource (Solar, Diesel, etc.) and the respective demand for water. For example, if the crops cultivated by the farmers only require 3 months of irrigation, then Diesel pumps may be more feasible due to the greater flexibility of matching the supply with the demand.

### 3.2 Solar Pumping Value Chain

Critical components the solar PV (photovoltaic) value chain offers several possibilities for companies from different industrial sectors, although the main value of the value chain is created along the solar panel manufacturing process. A general overview of the value chain for solar photovoltaic is given with the following figure, showing the key manufacturing steps and the necessary components.

As the wafer manufacturing and the module assembly usually represent the highest value of the installation costs (around 60 %), the manufacturing process is described in detail.

► **Wafer production (Panel)**: Based on the used technology, the crystalline (mono or polycrystalline) structure is growing and forming an ingot. The resulting structure is cut into blocks, cropped and afterwards sawed into the wafer. Wafers are doped in order to create n-type and p-type wafers.

► **Cell manufacturing**: The solar cell is built together as a sandwich structure, using the different doped wafer layers and a glass as top surface and a waterproof sheet as bottom surface. In order to provide a high efficiency of the glass surface, so called "solar glass" is necessary which needs low iron sand as raw material. The sandwich structure is equipped with the necessary electrical contacts and an anti-reflective coating is applied on the glass surface. In general, the solar cell manufacturing plants are capital intensive, resulting in a centralized production facility serving a whole region.

► **Module manufacturing**: Several solar cells are soldered together. This cell string is laminated between toughened glass on the top and a polymeric backing sheet on the rear. Additional frames are applied to allow for mounting in the field. The assembly of cells to modules is mostly carried out in the cell plant, but can be done in smaller plants closer to the end market as cells are relatively inexpensive to transport compared to modules. The capital costs for the module manufacturing are lower than for the cell manufacturing process.

► **Final assembly**: Mechanical and electrical integration of the different modules can be located at the site. This process step is not very capital intensive but labor intensive and therefore an **important component of job creation effects**. During final assembly, the basements and the support structure for the solar modules are installed and afterwards the PV modules are mounted. All necessary electronic components (inverter, grid connection, etc.) are installed and the cables for the PV modules are installed. Along the value chain, different jobs are created to produce, build and operate the solar PV-plant. Direct jobs are created at the PV production site, at inverter manufacturers and at construction companies. At the wafer and solar cell/module manufacturing companies, these jobs also includes workers from all levels and skills from manufacturing workers, engineers to senior executives and administrative jobs.

### 3.3 Egypt – Identified Gaps and Recommendations

**Focus on high priorities**

Define a national plan for Solar Pump System manufacturing:

**Market barrier**

At the moment, there are only a few incentives implemented supporting the local solar pump system industry in Egypt. To enable a secure investment environment for the industry, reliable frame conditions for the implementation of new production lines or the investment in new equipment is necessary.

**Recommendation: develop an overall master plan to support Solar Pump System component manufacturing industry in Egypt**

The master plan should include already existing supporting mechanisms and develop further steps covering all relevant Solar Pump System technologies,. The master plan should be divided into the different technologies and focus on their particular needs. For solar pump, the industrial value chain must be developed starting from the end (installation of systems and module manufacturing). **Inform on market size and feasibility of production lines concerning Solar Pump System**

Growth opportunities for their sector. **Conduct awareness-raising initiatives**

**Market barrier:**

Additional efforts must be taken into account to support the local manufacturing industry for Solar Pump-systems.

**Recommendation:**

Based on the high investments necessary downwards the value chain, it is recommended to establish supporting mechanism upwards the value chain. Awareness-raising initiatives especially focused on small and medium enterprises active in the manufacturing, installation and maintenance of electrical systems. Those companies could develop new business with small scale Solar Pump-system or roof-top installation. Larger companies could invest in new production lines for Solar Pump System-e manufactures. Due to the large competition within the Solar Pump sector local initiatives directly supporting the industry downwards the value chain must be designed diligently considering the international market and competition conditions in order to prevent. **Support research and development (R&D)**

**Market barrier:**

Local R&D-development for the solar pump system is a key factor to strengthen the local industry innovation potential and to provide skilled workforces. The already existing R&D-potential on academically and industrial level should be extended, coordinated and clustered to ensure an optimal use of the existing resources in Egypt. As the Operation & Maintenance of the different RE-plants offers a significant

potential for local workforce, it must be also highlighted during education and training of local workforce.

**Recommendation:**

Cooperated development (with participating of public authorities, industrial and academic representatives) of a national R&D-plan to support the technology development of renewable energies in Egypt. **This R&D-plan should include**:

► A long term framework for provision of public and private R&D-funds to support new and also ongoing basic research related to all kind of renewable energies in Egypt. National and international exchange programs for students and senior researcher should be established and supported by R&D-funds to provide a broad access to the current state-of-the Art and developments in the renewable energy sector; a R&D specific industrial platform to identify common goals of the academic and industrial sector.

► A training platform to ensure an adequate training of all skill-levels (academic researcher, technical management, technicians) and to provide the necessary training infrastructure (e.g. master courses, training-on-the-job, training centers). This training should include manufacturing specific skills as well as the necessary knowledge for operation and maintenance of different renewable energies. This cooperated development could lead to a national "Cluster of renewable energies in Egypt" combining all R&D-developments in Egypt concerning renewable energies. Identify niche technologies

**Market barrier:**

As renewable energies based on solar PVP and wind are a fluctuating source of electricity they will have a huge influence on the grid stability of the Egypt transmission network. Furthermore, most potential sites, especially for onshore wind are placed in locations with weak connection to the transmission network. **Therefore gird stability will be a major issue for Egypt with increasing share of renewable energies**.

**Recommendation:**

To provide adapted energy generation units to force this problem could be a promising R&D-topic for Egypt, developing solutions for the national and international electricity market. **Possible areas of interest are:**

► Hybrid plants as combining fossil fuels with PV, CSP (like the Kuraymat ISCC-plant) or wind;

► Low cost electricity or energy storage options, adapted to the Egyptian market and environment;

► Optimized grid integration concepts. Sustainable investments. local banks to implement low interest loans and grants.

**Market barrier:**

In order to support the implementation of investment supporting mechanism for adaption or creation of new production lines, local banks are interested to invest into productions lines of local manufacturer if a sustainable local market is observable.

**In summary – key actions**

Based on the detailed recommendations presented in this section, a summary of key actions that could be initiated in the short term (in the upcoming 12 months) are listed below:

- Review of the existing Solar Pump System regulatory framework regarding the possibility of including a supporting scheme for energy storage system (either thermal or electrical;.
- Develop an overall master plan to support Solar Pump System component manufacturing industry in Egypt;
- Conduct feasibility study for a selection of most relevant sites in different regions within Egypt for the implementation of Solar Pump System -plants;
- Awareness-raising initiatives especially focused on small and medium enterprises active in the manufacturing, Installation and maintenance of electrical systems;
- Develop a national R&D-plan to support the technology development of renewable energies and the identification of niche technologies;
- Extend the soft loan program for domestic and roof top application with a capacity smaller than 500 kW;

# 4. Over of the legal and administrative requirements as well as of the existing support and financing mechanisms in this report

## 4.1 Laws Relating to Irrigation

**The legal framework** for water resources management in terms of irrigation and drainage is established in specific laws and decrees. Irrigation laws are mainly enforced by the Ministry of Water Resources and Irrigation. The most important laws in this respect are:

**Law No. 12/1984** on irrigation and drainage regulates the use of water, including groundwater. It controls water rights, sets priorities between users, defines beneficial and harmful water uses and regulates financial aspects and penalties. The laws define the use and management of public and private sector irrigation and drainage systems including main canals, feeders and drains.

**Law12/1982** defines inter alia public properties related to irrigation and drainage, for example the River Nile, the main canals, public feeders and public drains and their embankments. The law regulates the use of groundwater and drainage water (construction of wells or the use of drainage water and water umps). It provides the regulations for the development of new land and the price that has to be aid for the irrigation and drainage of land

## 4.2 The Executive Regulations of the Law of Irrigation and Drainage

### *4.2.1 Groundwater*

**Article 18**

The state authorities, local departments, other governmental or non-governmental authorities or individuals shall not be allowed to authorize or carry out digging groundwater wells whether deep or surface in all the lands of the Republic except via a license from the Ministry of Irrigation and in conformity with the stipulations set by the Ministry.

**Article 19**

The owners of the groundwater wells that are dug before the effectiveness of the irrigation and drainage law referred to shall be committed to inform the Ministry of Irrigation within a year from the validity of this bylaw or announcement in the newspapers with the data regarding the wells that they hold. The wells whose diameters do not exceed two inches shall be excluded. The notification should include the following:

**1-** Name and address of the owner of the well.
**2-** Location of the well on a survey map with a scale 1:2500.
**3-** Data regarding the well in terms of the diameter of the well, the diameters and lengths of the pipes used whether solid or hollow, type of the pump installed on the well, its diameter, its discharge, and the average daily operating hours.

**4-** Date of digging the well, the date of starting the pumping and water withdrawal.
**5-** Degree of water salinity and water chemical analysis if present.
**6-** Purpose of using the well's water.
**7-** Area to be irrigated by the well's water and type of the cultivated crops.
**8-** The license issued for digging the well if there is any.
**9-** The water discharge authorized to be withdrawn from the well.

Notification shall be done via a registered letter or delivery by virtue of a receipt to the Irrigation Engineer in whose area of competence the well is located.

**Article 20**

The Ministry of Irrigation shall establish records at the level of irrigation districts that would include data concerning the wells authorized to be dug.

**Article 21**

The Ministry of Irrigation shall conduct a periodic revision of the notifications submitted to it according to article (19). The Ministry shall also carry out the necessary examination of the wells and express its observations regarding every location and send a copy of the data sent to it and the result of the examination to the Groundwater Research Institute that follow the Water Research Center for studying and giving the final opinion in its regard.

**Article 22**

The Irrigation General Director shall not be allowed to issue or renew license for an existing well except after the approval of the Groundwater Research Institute.

**Article 23**

In case of the lack of approval of the Groundwater Research Institute or the request of making some modifications in the well components or its water, the Irrigation General Director should inform the owner of the well via a registered letter for completion of what is required within three months from the date of notification and reporting that to the Irrigation Engineer and the Groundwater Research Institute for studying and giving the final opinion.

**Article 24**

The Irrigation General Director shall withdraw the license of the well or refuse its renewal and stop the pumping via the administrative way if the owner of the well does not respond for making the modifications demanded by the Groundwater Research Institute within the period referred to in the previous article or if the examination and study prove the incompetence of the works done by the owner of the well.

**Article 25**

Applications for obtaining license for digging the wells at the lands of the Delta and the Nile Valley stated in clause (a) of article (17) shall be presented to the provincial Irrigation Engineer in whose area of competence the proposed well is located. The

application form should bear the official stamps and include the data required, with the following documents enclosed:

1. Name and address of the license applicant.
2. Location of the proposed well on a survey map with a scale 1/2500 of three copies.
3. A copy of all the studies, analyses and designs related to the well if there is any.
4. Purpose of the use of the well's water.
5. Area to be irrigated by the well's water if the purpose of the well is irrigation.
6. Title deeds of the land utilizing the well or a certified statement from the agricultural cooperative society that proves his ownership of that land or a resolution for allotment of the land to be irrigated.
7. Paying a temporary insurance amounting to 200 pounds (two hundred pounds).
8. The well's owner should provide the irrigation district that the well follows with the results of water analyses and layers of the authorized well after completion of digging.

In case of lack of the owner's commitment, the insurance stated in item 7 of the same article shall not be paid back to the owner.

**Article 26**

The competent Irrigation Inspection shall undertake the study of the application of the license in terms of how bad the location needs water, the required uses, and determination of the discharge necessary for fulfilling the proposed needs.

**Article 27**

The Irrigation Director shall refer the license application with its enclosures accompanied by his own opinion based on the study to the Groundwater Research Institute for a more detailed study of the project and determination of usability of the location for employing groundwater, and defining the discharges available for use as well as the technical provisions and specifications that should be abided by. The applicant of the license shall be given the result within a period not exceeding two months from the date of submission of his application bearing the official stamps either by giving him a final license or a temporary permit for digging a test well and continuing all the necessary studies on it provided that the task should be accomplished by the license applicant at his expenses and responsibility. The license applicant should present a copy of all the data related to the well to the competent Irrigation Inspector so that the Irrigation General Director may issue the final license of the well.

**Article 28**

The contractors of digging the wells, public and private companies shall be prohibited to dig groundwater wells for governmental ministries or authorities, local departments, public or private sector companies, or individuals unless the well is authorized from the Ministry of Irrigation. The Ministry in that case should carry out any executive works otherwise the contractors shall be held accountable.

A copy of the results of digging any wells should be presented after completion to the Irrigation Engineer in whose area the well is located.

**Article 29**

The license should include the following data:

- The license number.
- The licensee name and address.
- The location of the licensed well.
- The purpose of the utilization of the well.
- The well's depth.
- Pipes' diameters, length, type and diameter of the pump authorized for use.
- The discharge authorized to be drawn from the well (m3/day).
- Duration of the effectiveness of the license.

**Article 30**

The license should not exceed three years. The application for renewal should be presented at least two months before the expiry. The license shall end when it is expired without renewal.

**Article 31**

In case of the request of obtaining license for digging groundwater wells in desert land subject to the provisions of law 143 for the year 1981 referred to and stated in clause (b) from article 17, the application of the license shall be submitted to the Public Authority for Agricultural Development and Reconstruction Projects. The application should bear the official stamps and contain the data with the documents referred to in article 25 from this regulation, provided that the temporary insurance should be to the credit of the Ministry of Irrigation.

**Article 32**

The Public Authority for Agricultural Development and Reconstruction Projects shall conduct the necessary studies in a period not exceeding six months from the date of submission of the license application and send the head of the Irrigation Sector at the Ministry of Irrigation a copy of all the data, studies, specifications and stipulations that were done regarding the submitted license application accompanied with its final opinion.

**Article 33**

The head of the Irrigation Sector at the Ministry of Irrigation shall refer the application of the license to the Groundwater Research Institute, then to the competent Irrigation General Director for issuance of the necessary license after obtaining the approvals of The Public Authority for Agricultural Development and Reconstruction Projects and the Groundwater Research Institute.

**Article 34**

The Ministry of Public Works and Water Resources in case of rejection of the license application should inform the applicant with a registered letter containing the reasons for rejection in two months from the date of submission of application. The applicant shall have the right to complain within thirty days from the date of being notified of the rejection of the license.

**Article 35**

The complaint should be presented to the Ministry of Irrigation. The Ministry should examine and judge the complaint in thirty days from the date of receiving the complaint. Its resolution in this regard shall be deemed final.

**Article 36**

Without prejudice to the penalty stated in article 95 from the Irrigation and Drainage law, the compensation shall be three piasters per cubic meter of excess water in case of surpassing the rates and amounts of water authorized for pumping.

**Article 37**

A copy of the license shall be sent to the following authorities:

1. Groundwater Research Institute.
2. The Public Authority for Agricultural Development and Reconstruction Projects as regards the wells authorized in desert lands.

**Article 38**

In case of loss or damage of the license, the Irrigation Public Department issuing the license should be immediately informed for obtaining a substitute.

### *4.2.2 Water Lifting Devices*

**Article 50**

For licensing to establish or run pump or any of the devices moved by a stationary or mobile machine running with the mechanical ways for lifting water for irrigating or draining the lands, the following shall be stipulated:

1. Submission of the license application bearing the necessary official stamps to the Provincial Irrigation Inspector.
2. Submission of a map with a scale 1: 2500 with three copies, of which one is signed by a syndicate engineer and illustrating the location of the pump or device.
3. Payment of examination fees amounting to ten pounds.
4. Submission of the title deeds of the land utilizing the pump, device and the documents of ownership of the machine or a statement certified from the competent agricultural society stating the agreement of the owners of the command area using the machine.

5. The pump's diameter or a general description of the device, the power of the machine and the discharge regarding the pump or device.

**Article 51**

Those who trade in the devices specified for lifting irrigation and drainage water should inform the competent Machines Inspection Office and the Irrigation Public Department in the governorate of every purchase or disposal of the devices within fifteen days from the date of disposal of the device. The notification should include the following data :

1. Name and address of the store that sold the device or pump.
2. Name and address of both the purchaser and the owner of the machine, numbers of their identity or family cards and place of issuance.
3. Purpose of purchasing the device or pump.
4. The authority in which the device is operated.
5. Mark, number, and producing company of the machine.
6. Diameters of the suction and ejection pipes, or a general description of the device and the power of the machine and the discharge of the pump or device.

**Article 52**

In implementation of the provision of article 74 of Irrigation and Drainage Law, the charge for lifting water shall be determined as follows:

1. Half a piaster per cubic meter of water taken for exploitive purposes of irrigation water lifted by governmental pumps.
2. A piaster per cubic meter of water cast after being processed by factories into the drains whose water is drained by governmental pumps.

**Article 53**

Wasting irrigation water via draining it in a private or public drain or land that is uncultivated or unauthorized for irrigation or cultivating rice without a license shall be prohibited. Seven piasters are to be collected for every cubic meter of water that the land planter either draws in excess of what is allocated for irrigating his land or causes to be wasted.

**Article 54**

Without prejudice to the penalties stated in the Irrigation and Drainage Law**,** the violator shall be committed to pay the charge for utilization for the period in which he encroaches upon the territories of irrigation and drainage. The competent Irrigation Department shall collect the charge for the utilization according to what is stated in supplement number two enclosed with this regulation**.**

**Article 55**

Whoever violates the authorized method of irrigation for irrigating the new lands which would in turn lead to draw amounts of water in excess of what is followed in the authorized irrigation method for irrigating his land, shall be committed to pay

three piasters per cubic meter of water that is drawn throughout the duration of the violation.

# 5. Analysis of the composition of the value chain in this market segment, including of those parts of the value chain in this market could take over (possibly following a more deliberate support policy by public authorizes

## 5.1 What is the Value Chain?

**Definition**: A value chain is a sequence of target-oriented combinations of production factors that create a marketable product or service from its conception to the final consumption. This includes activities such as design, production, marketing, distribution and support services up to the final consumer. The activities that comprise a value chain can be contained within a single firm or divided among different firms, as well as within a single geographical location or spread over wider areas.

**Value Chain** Development is in the meanwhile used as a technical approach by many international development agencies. Value Chain Promotion Component is the most prominent and successful. However, the approach is mostly used for regional or national development of particular sectors – only rarely for local (or rural) economies and sectors. This guide intends to fill the gap. The target of a Local Value Chain Development (Local-VCD) project divides itself into a primary and secondary target.

### *5.1.1 Primary Target*

Integrating the local sector the primary target is to improve the integration and position of local enterprises into a particular value chain. Local-VCD is a local initiative aiming at improving the competitiveness and market integration of a local sector. However, by linking up local enterprises to the national economy, larger business stakeholders at the upper end of the chain will ultimately benefit from an improved supply basis. Or the other way round: supply companies will benefit from an improved local market to sell their input products and services.

### *5.1.2 Secondary Target*

Developing other value chain levels the development of value chain levels which are not part of the local economy (e.g. national-level retailers and exporters) is only a secondary target. Whether or not you will be able to also address these levels, is determined by your resources and the outreach/influence of your organization. Certainly, improving the situation of national retailers and exporters will ultimately benefit the local sector, but the idea behind Local-VCD is to focus on immediate solutions and solutions which local stakeholders themselves can also implement. More important than improving the particular situation of value chain levels outside of the local economy is the relationship between them and your local target sector: Always keep in mind: value chain development is all about improving cooperation and coordination along the value chain.

### *5.1.3 Solar PV Value Chain*

Critical components:

The solar PV (photovoltaic) value chain offers several possibilities for companies from different industrial sectors, although the main value of the value chain is created along the solar panel manufacturing process. A general overview of the value chain for solar photovoltaic is given with the following figure, showing the key manufacturing steps and the necessary components.

**How does your organization create value?**

How do you change business inputs into business outputs in such a way that they have a greater value than the original cost of creating those outputs?

This isn't just a dry question: it's a matter of fundamental importance to companies, because it addresses the economic logic of why the organization exists in the first place.

Manufacturing companies create value by acquiring raw materials and using them to produce something useful. Retailers bring together a range of products and present them in a way that's convenient to customers, sometimes supported by services such as fitting rooms or personal shopper advice. And insurance companies offer policies to customers that are underwritten by larger re-insurance policies. Here, they're packaging these larger policies in a customer-friendly way, and distributing them to a mass audience.

The value that's created and captured by a company is the profit margin:

Value Created and Captured – Cost of Creating that Value = Margin

The more value an organization creates, the more profitable it is likely to be. And when you provide more value to your customers, you build competitive advantage.

Understanding how your company creates value, and looking for ways to add more value, are critical elements in developing a competitive strategy. Michael Porter discussed this in his influential 1985 book "**Competitive Advantage**," in which he first introduced the concept of the value chain.

A value chain is a set of activities that an organization carries out to create value for its customers. Porter proposed a general-purpose value chain that companies can use to examine all of their activities, and see how they're connected. The way in which value chain activities are performed determines costs and affects profits, so this tool can help you understand the sources of value for your organization.

Rather than looking at departments or accounting cost types, Porter's Value Chain focuses on systems, and how inputs are changed into the outputs purchased by consumers. Using this viewpoint, Porter described a chain of activities common to all businesses, and he divided them into primary and support activities, as shown below.

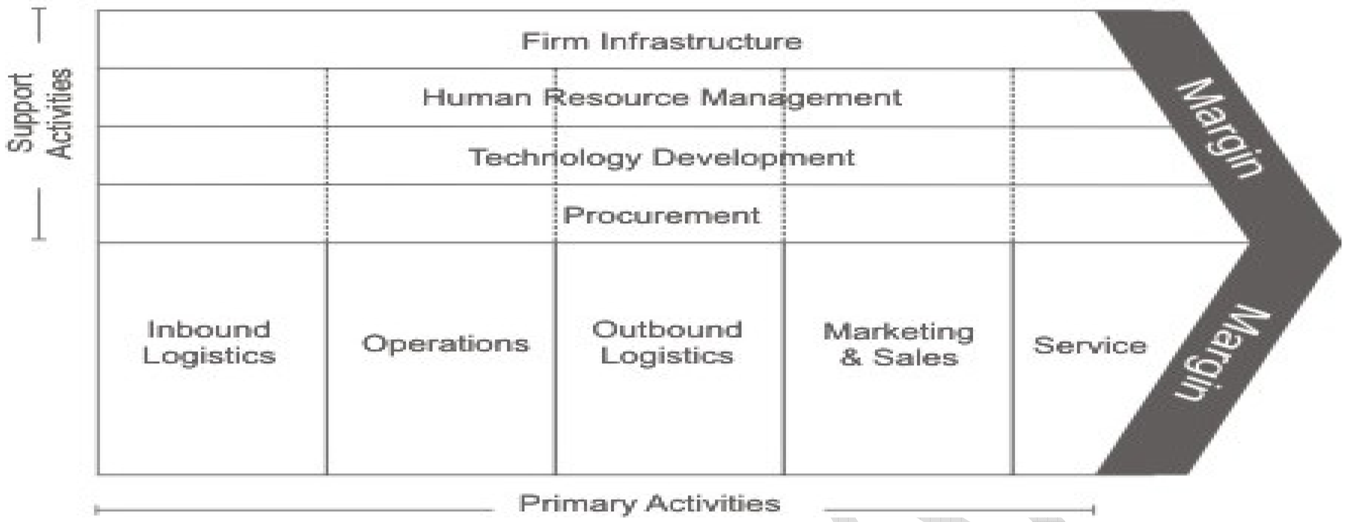



**Figure 20: Porter's Generic Value Chain**

### *5.1.4 Primary Activities*

Primary activities relate directly to the physical creation, sale, maintenance and support of a product or service. They consist of the following:

- **Inbound logistics**– These are all the processes related to receiving, storing, and distributing inputs internally. Your supplier relationships are a key factor in creating value here.
- **Operations**– These are the transformation activities that change inputs into outputs that are sold to customers. Here, your operational systems create value.
- **Outbound logistics**– These activities deliver your product or service to your customer. These are things like collection, storage, and distribution systems, and they may be internal or external to your organization.
- **Marketing and sales**– These are the processes you use to persuade clients to purchase from you instead of your competitors. The benefits you offer, and how well you communicate them, are sources of value here.
- **Service**– These are the activities related to maintaining the value of your product or service to your customers, once it's been purchased.

### *5.1.5 Support Activities*

These activities support the primary functions above. In our diagram, the dotted lines show that each support, or secondary, activity can play a role in each primary activity. For example, procurement supports operations with certain activities, but it also supports marketing and sales with other activities.

- **Procurement (purchasing)**– This is what the organization does to get the resources it needs to operate. This includes finding vendors and negotiating best prices.

- **Human resource management**– This is how well a company recruits, hires, trains, motivates, rewards, and retains its workers. People are a significant source of value, so businesses can create a clear advantage with good HR practices.

- **Technological development**– These activities relate to managing and processing information, as well as protecting a company's knowledge base. Minimizing information technology costs, staying current with technological advances, and maintaining technical excellence are sources of value creation.

- **Infrastructure**– These are a company's support systems, and the functions that allow it to maintain daily operations. Accounting, legal, administrative, and general management are examples of necessary infrastructure that businesses can use to their advantage.

Companies use these primary and support activities as "building blocks" to create a valuable product or service.

## 5.2 Using Porter's Value Chain

To identify and understand your company's value chain, follow these steps.

### *5.2.1 Step 1 – Identify Sub Activities for Each Primary Activity*

For each primary activity, determine which specific sub activities create value. There are three different types of sub activities:

- **Direct activities** create value by themselves. For example, in a book publisher's marketing and sales activity, direct sub activities include making sales calls to bookstores, advertising, and selling online.

- **Indirect activities** allow direct activities to run smoothly. For the book publisher's sales and marketing activity, indirect sub activities include managing the sales force and keeping customer records.

- **Quality assurance** activities ensure that direct and indirect activities meet the necessary standards. For the book publisher's sales and marketing activity, this might include proofreading and editing advertisements.

### *5.2.2 Step 2 – Identify Sub Activities for Each Support Activity.*

For each of the Human Resource Management, Technology Development and Procurement support activities, determine the sub activities that create value within each primary activity. For example, consider how human resource management adds value to inbound logistics, operations, outbound logistics, and so on. As in Step 1, look for direct, indirect, and quality assurance sub activities.

Then identify the various value-creating sub activities in your company's infrastructure. These will generally be cross-functional in nature, rather than specific to each primary activity. Again, look for direct, indirect, and quality assurance activities.

### *5.2.3 Step 3 – Identify Links*

Find the connections between all of the value activities you've identified. This will take time, but the links are key to increasing competitive advantage from the value chain framework. For example, there's a link between developing the sales force (an HR investment) and sales volumes. There's another link between order turnaround times, and service phone calls from frustrated customers waiting for deliveries.

### *5.2.4 Step 4 – Look for Opportunities to Increase Value*

Review each of the sub-activities and links that you've identified, and think about how you can change or enhance it to maximize the value you offer to customers (customers of support activities can internal as well as external).

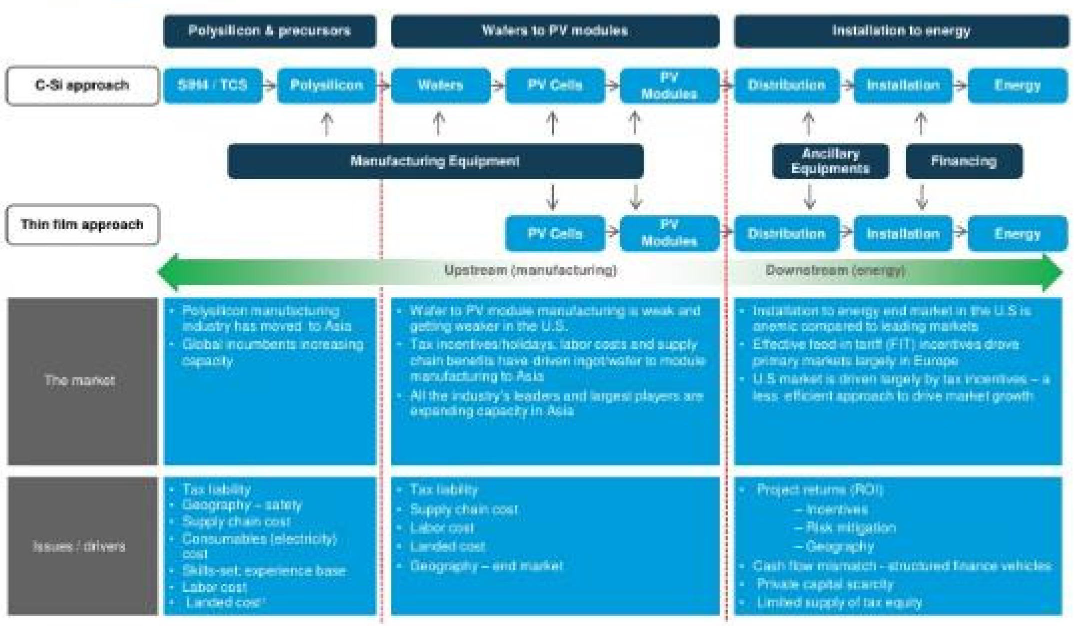



**Figure 21: Product and Services for Value Chain**

First, the organization's value chain should reflect its overall generic business strategies. So, when deciding how to improve the value chain, it should be clear about whether we are trying to set ourselves apart from our competitors or simply have a lower cost base. So we to create direct and indirect job. We should improve the performance of the PV Solar Pump system by:

## 5.3 Procurement Plan

**Statement of Work (SOW)**

a. **Scope of Work:**
Describe the work to be done to detail.
Specify the hardware and software involved and the exact nature of the work.

b. **Location of Work:**
Describe where the work must be performed.
Specify location of hardware and software where people must perform the work.

c. **Period of Performance:**
Specify when the work is expected to start and working hours, number of hours that can be billed per week, where the work must be performed, and related schedule information.

d. **Deliverables Schedule:**
List specific deliverables, describe them in detail, and specify when they are due.

**e. Applicable Standards:**
Specify any company or industry-specific standards that are relevant to performing the work.

**f. Acceptance Criteria:**
Describe how the buyer organization will determine if the work is acceptable.

**g. Special Requirements:**
Specify any special requirements such as hardware or software certifications, minimum degree or experience level of personnel, travel requirement and so on.

Second: We inevitably end up with a huge list of changes. We have to set our prioritization if you're struggling to choose the most important changes to make. (Alternative Plans if we need)

1. **Bid Solicitation**
   Vendor List (Either International Vendors or Internal Vendor List, a clear definition of the requirement; bidder instructions; bid preparation instructions; clear evaluation procedures; certification requirements; security and financial requirements; validity of the bid; resulting contract clauses;

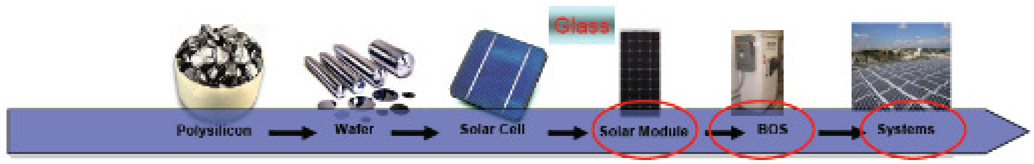
2. **Placing Purchase Orders (Durations of receiving Goods)**

3. **Contract Management**: Agreement Terms, Date of effect, Term, Products, Schedules of delivery and payment, Service Level Agreement, Responsibilities, Use of Subcontractors, Change Control, Warranties, Acceptance Letters, Confidentiality, Intellectual Property and Branding, Limitations to Liability, Termination, Applicable Laws, Risk Management.

4. **Receiving Goods (Sea Freight – Customs): Cargo, Transportation, Installation at Site**

Third: We look at the idea of a value chain from a broad, organizational viewpoint, and uses an approach that is also useful at a team or individual level.

Inventory Management System: Inventory that is not production / operations related to the needs to be segregated and separately accounted for the controlled. These are some of the categories of stock: Service levels, Customer banks, Design and Development labor, Safety supplies, foreign supplies, Discount stock, Export holding, customer delay, Credit holding, Customer delay, Marketing, Sales, Phased-out parts, Prototype inventory, movement and Inventory Policy




| | Polysilicon | Wafer | Solar Cell | Solar Module | BOS | Systems |
|---|---|---|---|---|---|---|
| Technology | HIGH | MED | HIGH | LOW | LOW | LOW |
| Jobs | MED | LOW | MED | MED/HIGH | MED | MED/HIGH |
| Major Competition | LOW | HIGH | HIGH | HIGH | HIGH | HIGH |
| Capital Intensity | VERY HIGH | HIGH | MED | MED LOW | LOW | LOW |
| Drivers | Power Cost<br>Technology<br>Regulatory<br>Huge Sites<br>High Volume<br>Incentives | Power Cost<br>Access to Poly<br>Incentives | Technology<br>Incentives | Labor Cost<br>Proximity to Markets<br>Connections to Cell Producer<br>Incentives | Incentives | Location<br>Labor Cost<br>Incentives |

**Figure 22: Solar Pump Irrigation Manufacturing Supply Chain**

**6. Translation of this analysis into informed scenario-based forecasts about the most likely future job creation effect (direct and indirect) as well as about the corresponding capacity building requirements (for workers and firms).**


According to IRENA, 2014, the employment dimension of renewable energy development is receiving growing attention. Around the world, policy makers are pursuing renewable energy technologies not only for greater energy security or environmental considerations, but also for the socio-economic benefits they generate. The renewable energy sector has become a significant employer, with the potential for adding millions of jobs worldwide in the coming years. Although no comprehensive global time-series data exist, evidence from individual renewable energy industries, especially wind and solar photovoltaic, for which there are better data than for other renewable energy technologies, as well as from selected countries, including Germany, Spain and the United States, highlights developments in more recent years. Wind power related employment has more than doubled in the past five years, while solar PV employment has soared nearly 13-fold.

Employment trends vary widely across renewable energy technologies. Jobs in solar photovoltaic have outpaced those in wind in the last three to four years have tripled in solar heating/cooling since 2005. The increase in biofuels capacity is leading the growth of employment while the mechanization of feedstock operations is reducing the related labour needs. Time-series data are lacking for other renewable energy technologies, but expanding capacity in both geothermal and small hydro sectors is translating into rising employment. A key question for job creation will be the future trajectories of renewable energy technologies, especially biofuels, which have seen considerable fluctuation and the trends in government support policies.

Recent trends in renewable energy costs and investment have had varying impacts on job creation in the different segments of the value chain. Renewable energy employment reflects regional shifts in renewable energy manufacturing, manufacturing overcapacities and industry realignments, growing export competition, and the impacts of austerity and policy uncertainty. It will be critical to gain a solid understanding of these trends as they continue to unfold. For instance, although declining costs of solar photovoltaic and wind equipment are introducing new challenges for suppliers and affecting manufacturing jobs, they are also driving growth in deployment and corresponding jobs in installation and

operations and maintenance. These shifts will affect the relative shares of employment and thus the overall occupational and skill patterns in the renewable energy sector.

Projections of future employment largely depend on assumptions about the scale of investments and capacity additions, which in turn depend on the supportive policies that are established, the trends in the cost of renewable energy technologies, and labour productivity. The latter will reduce employment over time, but may be compensated by large-scale deployment

In the IRENA RE map 2030 options, direct and indirect global employment in renewable energy used for power, buildings, transport and industry in 2030 would account for around 16.7 million jobs2,3. Of these, 9.7 million would be in bioenergy, 2.1 million in wind energy, 2 million in solar photovoltaic, 1.8 million in solar water heating, 0.6 million in small hydropower and 0.5 million in the other renewable energy technologies (concentrated solar power, landfill gas, geothermal, tidal, wave and ocean). If the REmap business as usual scenario is assumed, the total direct and indirect jobs in the renewable energy industry would be 9.5 million only, still a considerable increase from the current figure of 5.7 million.

## 6.1 The Importance of Measuring Employment From Renewable Energy

Despite recent improvements, major gaps remain in renewable energy employment data. Due to the crosscutting nature of the renewable energy sector, such information is difficult to capture in standard national statistics. Only a few countries are gathering relevant data on renewable energy jobs. In most cases, employment figures are derived from various sources, using heterogeneous methods, assumptions and time frames. The quality of existing employment data remains uneven, necessitating greater harmonisation of data reporting categories (IRENA, 2013).

Sound information on renewable energy employment is essential to enable informed policy choices. High quality data is critical to monitor policy effectiveness, and to support policy makers in communicating the benefits of these policies to the wider public with reliable facts and figures. The most valuable data distinguishes between direct and indirect employment in different segments of the value chain (fuel production, manufacturing, construction, installation, operations and maintenance, etc.), disaggregate across different parts of the renewable energy sector (agriculture, construction, manufacturing, services), provide occupational details (gender, wages, etc.) and differentiate between domestic and export-driven employment

The simplest and least resource-intensive method for assessing direct jobs is the employment factor approach. This is based on data for installed capacities, energy production and employment factors. However, the quality of the employment estimates depends largely on the accuracy and availability of country- and technology-specific data. Moreover, existing employment factors refer mainly to countries of the Organization for Economic Co-operation and Development. Therefore, caution is warranted when drawing specific conclusions from the available employment factors and would benefit from sensitivity analyses to account for specific country’s characteristics.

The supply chain, multiplier and Input-Output methods consider direct and indirect jobs, while full economic models broaden the scope of analysis to include net effects. These methods give a more comprehensive picture but tend to be more resource-intensive. Further increasing the sophistication of the analysis, full economic models capture the induced impact of renewable energy employment. The selection of the most appropriate method depends on the key questions, and the availability of underlying data and resources (human, financial, temporal, etc.).

Greater harmonization of the methods used to estimate renewable energy jobs would enable more accurate comparisons across different technologies and countries. With sufficiently standardised and detailed information and analysis, the employment effects of renewable energy policies would be better understood and policymaking better targeted to maximize the benefits.

### 6.2 Interactions Between Different Policy Instruments in Support of Job Creation

**A broad range of policies influence renewable energy job creation**. These include policies governing renewable energy deployment, trade, investment and research and development, as well as regional development and cluster formation. These policies are most effective when they are pursued in conjunction with each other, in concert with broader economic policies such as industrial, labour, and fiscal (IRENA, 2015).

**Steadiness and predictability in governmental** policies are important to ensure stability and continued growth in employment. Although governmental support policies need to adjust to changing market conditions, the experience of recent years demonstrates the need to avoid abrupt policy reversals which may put renewable energy jobs in jeopardy.

**Cross-border trade and investment flows are increasingly relevant to the renewable energy sector, with implications for employment.** To maximize domestic job creation opportunities, national policies need to be calibrated carefully depending on the strengths and weaknesses of a particular country. Capacities and opportunities vary across countries, depending on respective renewable energy resource endowment, stage of industrial development, and availability of a local skilled workforce.

**Careful policy consideration is needed with regard to local content requirements**. Many governments are adopting local content requirements, tied to deployment policies, in a push to establish local renewable energy industries. It is essential to pay attention to their design and to link them closely to a learning-by-doing process. To ensure the full-fledged development of an infant industry, local content requirements should not only be time bound, but also accompanied by measures to facilitate the creation of a strong domestic supply chain and a skilled workforce, and to advance research and development programmes.

**Industrial clusters, which facilitate information sharing and cross-pollination of ideas, can provide important benefits in the development of renewable energy capabilities**. A cluster typically refers to a geographic concentration of interconnected economic and innovative activities in a particular field. Clusters and regional policies involve a variety of economic actors, including government agencies, private businesses

and Labor policies Fiscal policies R&D, clusters and regional development Trade and investment policies Education policies Deployment policies Other industrial policies Figure 2 Schematic of key questions when choosing an approach to measure renewable energy employment 14 Renewable Energy and Jobs universities. Research and development is typically a crucial component of such efforts, often motivated by the need to overcome economic challenges, such as crises in older industries or lack of economic diversification. Governments can play an important role in setting the broad framework within which clusters can operate successfully, combining industrial, market-creating and business support policies, in order to fully mobilize the inherent potential.

**Renewable energy skills, education and training:** key enablers

High demand for qualified human resources in the sector is expected to continue, raising the potential for skills gaps and labor shortages. If not addressed in a timely manner, the shortage of necessary skills in the renewable energy sector could become a major barrier to the deployment of renewable energy. This can slow down progress, and installations performed by inadequately skilled personnel can result in performance issues and lead to a negative public perception of renewable energy technologies. Although renewable energy companies may be able to draw on experienced workers from other industries, this may not be a viable solution in the long term.

Successful deployment of renewable energy technologies requires forward-looking renewable energy education and training policies. There is a significant variation in the skills demanded in the renewable energy sector by occupation. Medium and high-skilled occupations, which require a certain level of education and training, are by nature more difficult to fill. Therefore, it is essential that the renewable energy sector strategy accounts for how skill needs in the future may evolve in the context of rapid technology changes.

In addition to renewable energy technology-specific skills, training programmes should also provide core technical and soft skills that increase workers' employment flexibility. In many countries, the majority of renewable energy jobs will be in installing, operating and maintaining renewable energy production facilities, rather than in manufacturing equipment. Therefore, workers need transferable skills that allow them to be employed flexibly in different jobs or projects. In the context of energy access, where the installations tend to be simpler, basic commercial skills, accounting, price design, inventory, quality assurance, etc., as well as marketing and after-sales service skills can be as important as technical skills.

Countries will be successful in the deployment of renewable energy technologies only if effective renewable energy education and training policies are in place. Policy makers have various ways of pro-actively include renewable energy topics in the existing and new educational programmes and institutions. This can be done by fostering the creation of interchangeable job and training specifications, harmonization of curricula and the development of common quality standards for training programmes and trainers.

**Off-grid solutions:** catalyzing local employment and economic growth

IRENA estimates that reaching the objective of universal access to modern energy services by 2030 could create 4.5 million jobs in the off-grid renewables-based electricity sector alone. This estimation provides an indication of the magnitude of the job creation potential if the other end-use sectors, i.e., heating/cooling and transport, are included. Local employment is more likely to be concentrated in assembly, distribution, installation, operations and maintenance and after-sales services, rather than in manufacturing.

Achieving universal access to modern energy services is a vital pre-requisite to advancing socio-economic development. In addition to national and local energy access programmes, several global initiatives, such as 4.5 million jobs in off-grid renewable electricity sector by 2030. The United Nations' Sustainable Energy for All initiative, have been launched to mobilize action towards achieving this goal. Decentralized renewable energy, in particular, can play an important role where extending the grid is more expensive or impractical, or the pace of extensions is slow. Off-grid renewable energy solutions are already cost competitive in many circumstances and bring high potential for job creation along the supply chain. Renewable energy jobs in rural areas vary significantly depending on the specific renewable energy technologies and the deployment approach adopted. The scale of off-grid renewable energy applications, typically much smaller than grid-connected, has implications for how they are distributed, installed and operated. This, in turn, affects the type and number of jobs involved and the types of technical and business skills required. Analysis of selected case studies also suggests that the characteristics and number of jobs depend largely on local variables such as social factors (e.g., family relations, societal structures), market-based factors (e.g., demand fluctuations, deployment model) and policy-based factors (e.g., employer legal obligations). There is growing evidence that decentralized renewable energy solutions can create value locally in terms of both employment and economic growth. This potential is considerably enhanced when renewable energy projects are well integrated with local commercial activities. The supply chain for solar photovoltaic systems and identifies segments that are typically domestic or import-driven (or a mix of both). Local enterprises play an increasingly important role in extending access through the adoption of innovative business models. In addition, many of the technical and commercial skills required can be developed locally, thereby enhancing the sustainability of local economic activities. Dedicated off-grid renewable energy policies are key to transforming rural economies. The adoption of an integrated programmatic approach specifically targeting the sector is necessary to achieve universal access to modern energy. As such, the provision of energy access should go beyond meeting basic needs to include energy services for productive uses to enable a range of downstream micro-enterprises for rural economies. A better understanding of the employment effects of different energy access approaches (e.g., number of jobs created by technology, type of employment, wages, skills and training requirements, gender dimension, etc.) can guide policy-making towards achieving the full potential of employment from renewable energy deployment. Gender dimensions of renewable energy employment Women's talents and insights remain under-utilized in the renewable energy sector. In both industrialized and developing countries, gender stereotypes are powerful inertial forces which continue to restrict women's participation in, and contribution to, the sector. However, the nature of the gender gap is vastly different in the modern energy context,

where the entire population has adequate access to energy, than in rural areas of the developing world, where women and children typically bear the burden of inadequate energy access.

One of the forces propelling renewable energy development is the potential to create new industries and generate millions of new jobs. Jobs from renewables now number in the hundreds of thousands in several countries. Globally, there are an estimated 3 million direct jobs in renewable energy industries, about half of them in the biofuels industry, with additional indirect jobs well beyond this figure. According to The Clean Edge Report (www.cleanedge.com), solar photovoltaics and wind power industries, the 2015 figures account for more than 190,000 and 413,000 direct and indirect jobs worldwide, respectively, a total of 63 more than 600,000 jobs. By 2018, it is projected that the number of jobs will surpass 1,341,000 for solar and 1,315,000 for wind, for a total of nearly 2.7 million jobs. Also, The Grid Wise Alliance Report (www.gridwise.org) refers 280,000 jobs to be created through smart grid. Greatly increased investment from both public-sector and development banks is also driving renewables development, particularly from banks based in Europe, Asia, and South America. The European Investment Bank and the Brazilian Development Bank (BNDES) are notable cases. A number of development banks have increased development assistance flows. Such flows jumped to over $5 billion in 2009, compared with some $2 billion in 2008. The largest providers are the World Bank Group, Germany‘s KfW, the Inter-American Development Bank, and the Asian Development Bank. Dozens of other development agencies provide growing amounts of loans, grants, and technical assistance for renewables.

Besides energy, renewable sources like wind also contribute to produce jobs and income. For every megawatt of new capacity, the annual market for Egyptian solar pump in 2016, created employment at the rate of 20 jobs (person years) per MW installed in that year through system installation, distribution transportation, and maintenance.

The supply chain analysis seeks to map the specific supply hierarchy and relationships among companies in an economic sector, focusing on different tiers of manufacturers and companies which provide key components and inputs. The approach generates direct jobs and, to some extent, indirect jobs. Compared with employment factors and Input-output analysis, supply chain analysis is used rarely. This could be because of data unavailability, the complexity of the analysis or its more business-management (i.e., micro) approach, which may not always be fully accepted by economists who normally deal with employment estimations at a more macro level. For migrating from Diesel Pump for Irrigation System to Solar Pumps for Irrigation system the following creation jobs are need:

1. **Performance Planning:**
   We first essential to plan how to change the old irrigation system by the new one as the Solar irrigation pumps need

New nozzles, wide diameters and new filters either two systems will work together or by alternative way till we finish installation of the solar pump system for irrigation (Installation of full irrigation system)

**Job Created** Project Management Engineer, Mechanical Engineer and Irrigation Engineer**. (Direct Jobs 3)**
**The above created jobs will be permanent jobs and they will work for about 10 hours per day and 5 days per week. Total working hours per week will be 50 hours.**

2. **Materials Planning:**

Warehouses function: **Receiving, Identifying, Sorting, and Dispatching to storage, holding goods**

**Recalling and assembling Dispatching shipments**

**Jobs Created: Indirect Jobs:** Inspector, Equipment Planning (Technical / Mechanical Engineer.
The above mentioned jobs are indicted job and according to the job need and requirements. If they work 3 days a weeks which means 30 hours per week.

**Jobs Created:** Trucker, Care Handler, Store Keeper, IT Specialist (Bar Coding, RFID coding), and Accountant **(5 Direct Jobs)**
**The above created jobs will be permanent job and they will work 10 hours per day and 5 days a week. Total working hours per week will be 50 hours**

**Jobs Created**: Handling Companies, Cargo, Transportation (Indirect Jobs). According to the necessity of the job. All the companies are working full time job

3. **Operations**: Manufacturers and Technician for PV Pump installation
**Job Created**: Engineers, Technicians, and Accountants.

4. **Distribution Channels (Out Bound): (3rd Party)**
Spare Parts and materials shops, small enterprises for distribution of the goods Distributors, Technician and also transportation from and to the field (10 Job Opportunities)

As a result from the above, Supply Chain Management plays a vital role in organization activities and essential element to operational efficiency which can be applied to reach our target. Let's say that it is just like the backbone of an organization which manager the critical issues of the business organization such as rapid growth, expansion and environmental concern which indirectly or dramatically affect the strategy:

Other benefits and importance to apply supply chain management are:

- Reduces Inventory Costs

- Provides better medium for information sharing between farmers Crowers
- Improve the quality of the cultivated land and the crops
- Maintains trust between partners
- Provides efficient manufacturing strategy
- Improve process integration
- Increase cash flow
- Improve quality and give higher profit margin

The total number of employment per kW is illustrated in Figure 23, while the number of employment per each stage per kW is illustrated in Figure 24. For example, the total number of employment for constructing 1MW is about 7771 man.

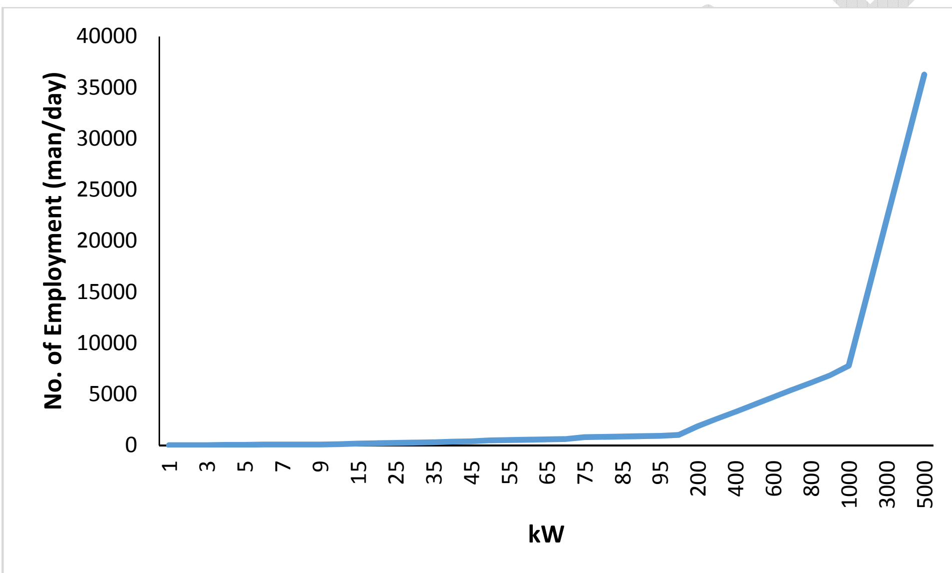



**Figure 23: Total Number of Employment per kw.**

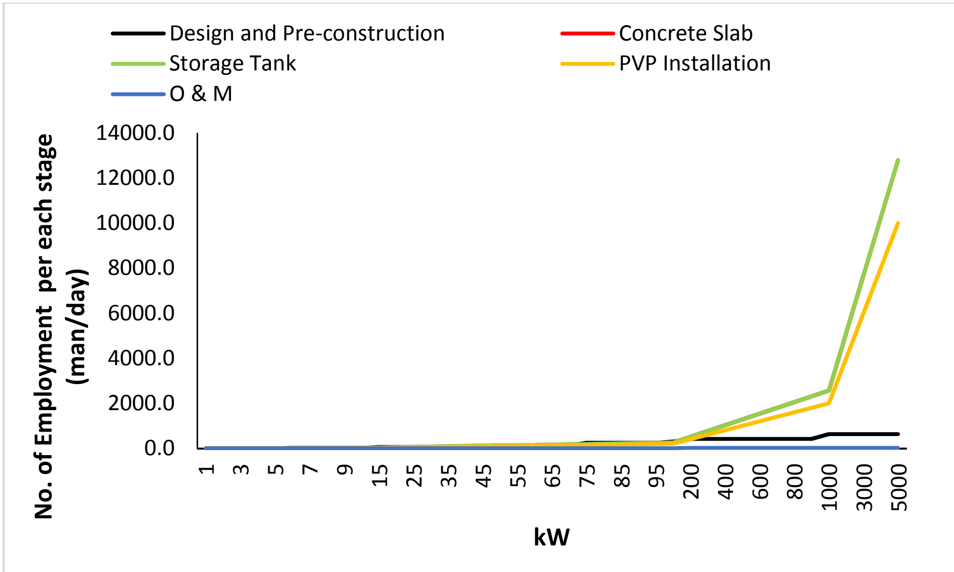



**Figure 24: Number of Employment per each stage per kw.**

## 7. Modeling of the data to estimate the potential market Size of river-based and ground water irrigation at the national level and each geographical area in order to identify hot spot where solar PV companies can focus their marketing and sales efforts.

Energy is essential for the social and economic progress for any country. This of course will lead to a huge increase in energy demand, which cannot be covered by fossil fuel for a long period of time. We are not only facing finite reserve of fossil energies, but also have to deal with the growing climate risks arising from their use. One of the main solutions to this dilemma is to exploit the enormous potentials of renewable energies, and by using manifold opportunities for increasing the energy efficiency with new technological solutions.

Several renewable energy technologies have made significant penetrations in the energy market. These technologies include solar (solar thermal and photovoltaic), wind, biomass, geothermal, hydro, wave, tidal and ocean thermal resources applications. The increased interest and rapid growth in these applications have been stimulated by a significant drop in cost over the previous decades, and technical improvement that have increased their efficiency, reliability and longevity. Other advantages of renewable energy applications are their modularity, large solar potential in developing countries especially in MENA region, favorable land-use features and ease of decommissioning (UNEP, 2007).

The leading technical improvements in this field includes: manufacturing, innovations, improvements in solar system design, conservation, efficiency improvements, aerodynamic advances in wind turbine design and other mechanical and electrical innovations.

**Targets for RE future in** (Egypt - 2010 -2020)

- 3% power generation from RE 850 MW wind installed capacity;
- 150 MW solar combined cycle power station. 20% power;

### 7.1 Barriers and Constrains to RE Deployment Egypt

Despite the environmental, social, health and economic (in some applications) benefits of utilizing renewable energy technologies, their utilization in EGYPT is nearly negligible until now. They are facing many barriers and constrains to their large deployment in this region. These include financial, Economic, institutional, political, and technical and information barriers.

### 7.2 Financial and Economic Barriers

The most important issue is the economic performance of renewable energy technologies compared to energy sources that presently dominate the energy market. The barriers in this area include:

- High specific cost of renewable energy technologies versus subsidized low fuel prices and electricity tariffs. This will cause a lack of willingness and/or ability to finance expensive investments in renewable energy technology because of high risk premiums.
- Taxes and customs on imported equipment. This will lead to increase the initial cost of renewable energy equipment’s.
- High transaction costs due to the small-scale and decentralized nature of some renewable energy technology applications. This will discourage the implementation of renewable energy projects.

### 7.3 Institutional and Political Barriers

Most of MENA countries are lack of an adapted and stable institutional and regulatory frame work for renewable energy utilization. These include: -Conflicting objectives and interests among policy-makers. This will shift power to fossil fuel lobbyists, hinder objective policy formulation, and lack of policy coherence.

- Institutions for renewable energy technology promotion are relatively powerless compared to institutions of fossil fuels. This will lead to government concentration on fossil energy
- Unclear Ministerial responsibilities and insufficient coordination between government agencies responsible for renewable energy technology. This will lead to weak promotion of renewable energy technologies.
- Monopolistic energy market. This will lead to no guaranteed grid access and no fair feed-in tariffs for independent renewable energy power producers which lead to keep renewable energy independent renewable energy power producers which lead to keep renewable energy Technologies out of the market.

### 7.4 Technical Barrier

The considerable international investment made in renewable energy R&D during the previous three decades has demonstrated the potential and technical availability of some of these technologies.

Even though renewable energy technologies are technically proven, additional development is still required to become fully mature. Among the barriers in this field are:

- Lack of technical standard and inappropriate technical designs. This gives renewable energy technologies a bad reputation, impeding their future dissemination.
- Some of renewable energy technologies and component (e.g. solar thermal power plant and large scale thermal storage) are not yet commercially tested. This increases the investment cost and financial risk for plant operators.
- Lack of social acceptance of some technologies (e.g. biomass) may hinder project implementation.

### 7.5 Awareness and Information Barrier

Consumers, engineers, architects, managers, bankers and policy maker may lack information about renewable energy technologies. This will lead to:

- Lack of awareness of potentials and benefits of renewable energy technology utilization among decision makers at different political and administrative level.
- Lack of qualified personnel. Problems in technical implementation, maintenance and financial arrangements hinder renewable energy technology market development in general.
- Insufficient resources for data collections and information transfer. This may lead to no, or wrong decisions by project developers, investors etc. -Inadequate and insufficient education of consumers and renewable energy systems user. This brings:

    - ✓ Technological mistrust in case of system breakdown. Submersible pumps are primarily used in rural areas for irrigation, where power supply is absent or unreliable. On average, 85% of the total costs of a pump operation is incurred as a result of its energy consumption over the pump's lifetime.
    - ✓ Underground water is a fundamental source of water supply for agriculture, livestock and survival in the Middle East. The few available solar pumping options are either highly expensive or with questionable quality. Solar pump systems offered from multinational brands cover up to 30kw. Due to the steep decline in water tables across the region, depths of bore wells are high, requiring large pumps which are not available in solar powered options In response to the two main problems of high price and limited range of solar pump systems, we plan to launch our own brand. Our systems will be the world's widest range reaching 185kw and will be offered at 30%-40% less than standard market price; with superior technical features superseding any current offering in the market.

Our primary target segment is farmers using submersible pumps for irrigation and livestock watering:

- **Egypt has thousands of wells used for** irrigation in Upper Egypt, Red Sea Province, and Northern Mediterranean coast and in the Western desert close to Libya borders. We will offer complete solar pump systems as well as stand-alone solar power packages to power already-installed electrical pumps; making the entire market, Egypt lies in a high solar insulation band and is blessed with high intensities of solar radiations and longer durations of sunshine hours and is endowed with abundant solar energy and good weather conditions most of the year [2]. According to the 1991 *Egyptian Solar Radiation Atlas*, the country averages between 5.4 and more than 7.1 kilowatt-hours per square meter ($kWh/m^2$) of annual daily direct solar radiation, from north to south. The annual direct normal solar irradiance ranges from 2,000 to 3,200 $kWh/m^2$, rising from north to south, with a relatively steady daily profile and only small variations in resource. Such conditions are supported by 9–11 hours of sunlight per day, with few cloudy days throughout the year [5].

- Thus, Egypt has very favorable solar resources for a variety of solar energy technologies and applications. It is estimated that Egypt's economically viable solar potential in the range of 74 billion MWh per year, or many times Egypt's current electricity production. The Energy Research Center at Cairo University's Faculty of Engineering estimates that 6 MW of solar PV are currently installed in Egypt. In addition, a 150 MW integrated-solar combined-cycle power plant is under construction in Kureimat, with a solar component of 30 MW. Egypt is recognised as having vast potential for solar energy application, but the investment cost of solar power plants is currently very high in comparison with oil and gas fired power plants.

- In the field of solar energy, New and Renewable Energy Authority's (NREA) future plan includes implementation of 100 MW solar thermal plant (financed in co-operation with KfW, World Bank and African Development Bank). KomOmbo site was selected to host the project. In addition, there are also two Photovoltaic plants with capacity of 20 MW in Hurghada and KomOmbo in co-operation with Japan.

- The solar water-pumping technology is commercially available, has-proven record of reliability, require, minimal skilled manpower once in operation, and operation and maintenance cost is also very minimal and affordable. PV-powered water-pumping systems have been installed and are operational in various parts of the globe including Egypt, and some of these installation dates back to early 1990s [2].

## 7.6 Losses in a Typical Solar PV Pumping System

### *7.6.1 Advantages*

**Low operating cost**: One of the important advantages is the negligible operating cost of the pump. Since there is no fuel required for the pump like electricity or diesel, the operating cost is minimal.

**Low maintenance**: A well-designed solar system requires little maintenance beyond cleaning of the panels once a week.

**Harmonious with nature**: Another important advantage is that it gives maximum water output when it is most needed i.e. in hot and dry months.

**Flexibility**: The panels need not be right beside the well. They can be anywhere up to 20 meters away from the well, or anywhere you need the water. These pumps can also be turned on and off as per the requirement, provided the period between two operations is more than 30 seconds (ENID, 2013).

### *7.6.2 Limitations*

**Low yield**: Solar pumping is not suitable where the requirement is very high. The maximum capacity available with solar is very low. However, the output of the solar DC pump is more than a normal pump.

**Variable yield**: The water yield of the solar pump changes according to the sunlight. It is highest around noon and least in the early morning and evening.

**Theft**: Theft of solar panels can be a problem in some areas. So the farmers need to take necessary precautions. Ideally, the solar system should insured against theft as well as natural hazards like lightning.

## 7.7 Potential of Solar Water Pumping in Egyptian Desert

The big problem currently facing agriculture in reclaimed Egyptian desert far away from an electrical grid is dependence on diesel powered generators that require difficult to deliver and expensive liquid fuels for their operation. Off-grid***1*** solar water pumps that recover underground water from deep wells for agricultural uses using solar energy applications serve the unique needs of Egyptians who live in desert landscapes. 1"Off grid" refers to areas that are off of Egypt's main power grid, which provides electricity to most of the country.

Solar water pumps offer Egyptians the opportunity to live in off-grid desert communities and have access to essential groundwater resources will help to pull population away from an overcrowded Nile and take advantage of the desert's abundance of sun and soil. It will open up a chance for Egyptians to find a new ways of making a living without having to depend on an unreliable electrical grid.

Still there are remote areas and smaller cities and towns which are not yet connected to **national electricity grid** and are dependent on power supply from diesel generating power stations and have isolated grids. Diesel engines are not only unreliable, but particularly harmful to the environment. Previously, off grid renewable energy solutions were not financially feasible to compete with these engines. Ground water is available in most of these areas but they require electricity and equipment to pump the water for domestic usage, irrigation, and cattle.

Water pumping has regularly been a technical challenge. Recently some farmers have begun to move outwards into the western desert to exploit the vast expanses of land, using diesel-powered pumps to pull up the groundwater for their crops. Diesel is cheap (the government subsidizes it) and the pumps run 20 hours a day. But they are noisy and polluting, and transporting diesel to these remote areas is costly and hard.

In the Egyptian desert, arable land is scarce and water almost nonexistent, so farming is a tough business. One resource you know you can rely on in a desert is plenty of sunshine, so some farmers in Upper Egypt have turned to harvesting the energy from the sun for irrigation. In Wadi El Natrun, situated far from mains electricity grids, the dry-climate fruits and vegetables grown are watered from wells deep underground. Once farmers used diesel generators to pump water for the fields, but now a self-contained concentrated photovoltaic (PV) system controls and manages an entire irrigation system. Where there is no public power grid, the PV systems currently operate cost-effectively, due to their low operating cost.

PV systems for the pumping of groundwater are also used in Upper Egypt, proving that the cost of the water unit pumped by PV systems is significantly lesser than that pumped by diesel systems [1]. Solar water pumps were first introduced for water provision in off-grid areas. The technology has developed around many different designs. Solar pumps are easy to install, require no nonrenewable energy, operate autonomously and are generally “good” for the sustainability of boreholes due to their low extraction volumes spread over eight to ten hours a day.

The initial capital cost is high due to the cost of the photovoltaic modules. The maintenance requirements differ and range between annual and five year maintenance intervals. A perceived limiting factor of solar pumps is that they do not easily cater for fluctuating water demands or increased water demand although solutions for this are being offered. Unlike conventional diesel or electrical pumps, solar photovoltaic (PV) pumps are powered by an array of solar panels. Solar PV pumps are designed to operate on DC power produced by solar panels. Solar PV pumps are becoming a preferred choice in remote locations to replace hand-pumps, grid-connected electrical pumps and diesel pumps. In such places, solar PV pumps are even viable economically in comparison to conventionally run pumps.

## 7.8 Determining Penetration Rate

### *7.8.1 Scenario Analysis for Renewable Energy Sector in Egypt*

According to Adel K. Khalil et. al, 2010, three scenarios are proposed for RE implementation in Egypt's electric power system, which has the largest market share and the most support facilities available.

The first scenario follows the existing plans of the Ministry of Electricity and Energy (MOEE) and is considered as the low scenario (business as usual);

The second is the medium scenario and the third is the high scenario. The high scenario includes a proportion of the proven technical potential of RESs in Egypt where there are ample renewable sources. It should be noted that the three scenarios are based on a constant requirement for energy produced and on different installed capacities. The difference in installed power capacities comes from the difference between the installed and demonstrated power via RES power generation. Figure 25 and Figure 26 show installed capacities and energy generation for recommended RETs in the high scenario. As an example, three scenarios are proposed for the replacement of conventional water heaters with SWHs. The first or soft scenario assumes a 2% annual replacement of electric water heaters. The second and third scenarios consider annual replacements of 3.5% and 5.5%, respectively. The estimated reduction in electrical energy consumption due to such scenarios is presented in Figure 27 and shows expected electrical energy savings of 4.9 billion kWh by the year 2015 for the high scenario.

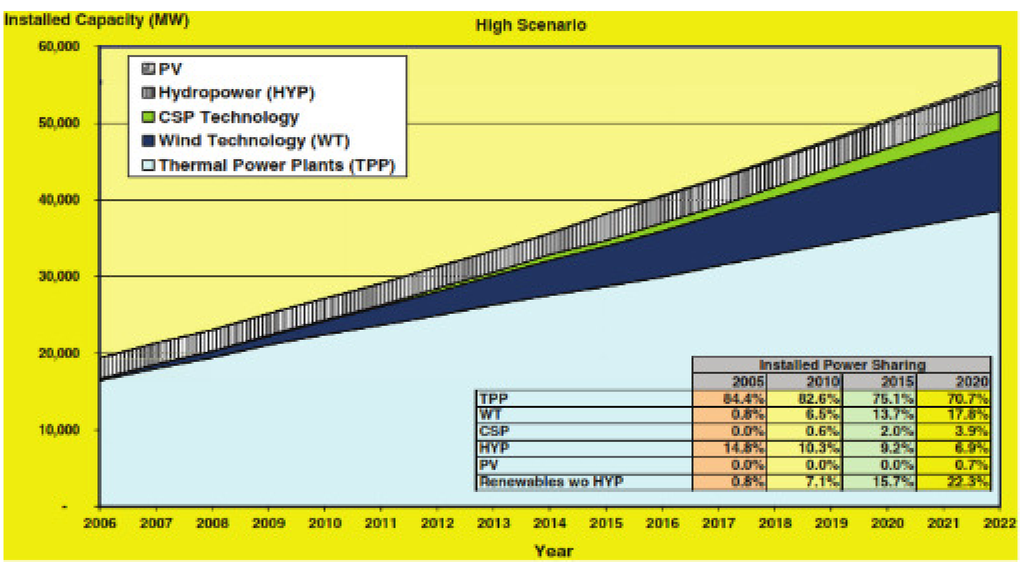



**Figure 25: Energy Generation Needs and Recommended Rets – High Scenario**

Source: Adel K. Khalil, et. al., 2010

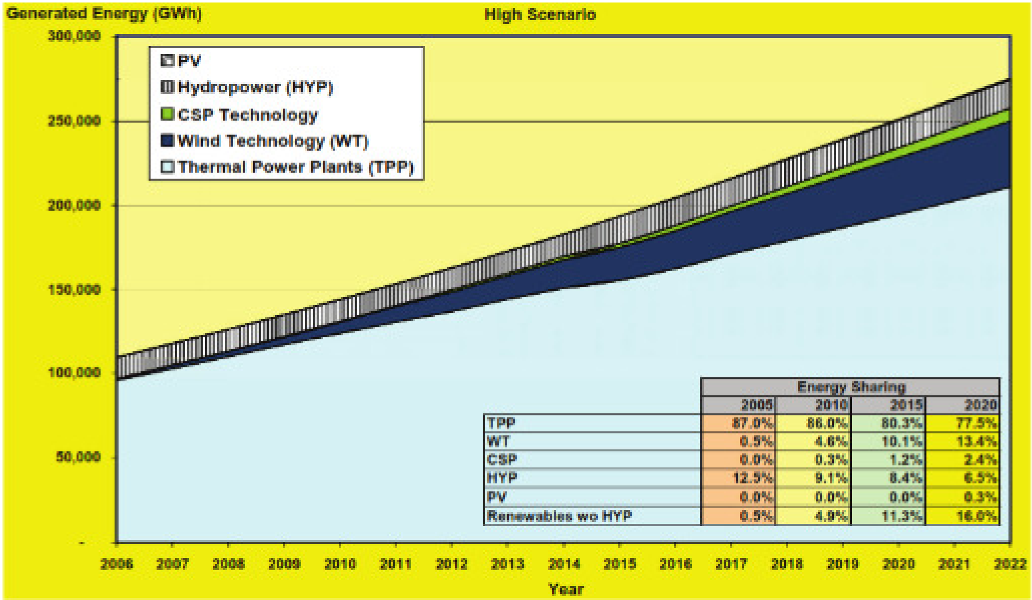



**Figure 26: Projected Electric Water Heaters Energy Consumption and Anticipated Reduction Due To SWH Scenarios**

Source: Adel K. Khalil, et. al., 2010

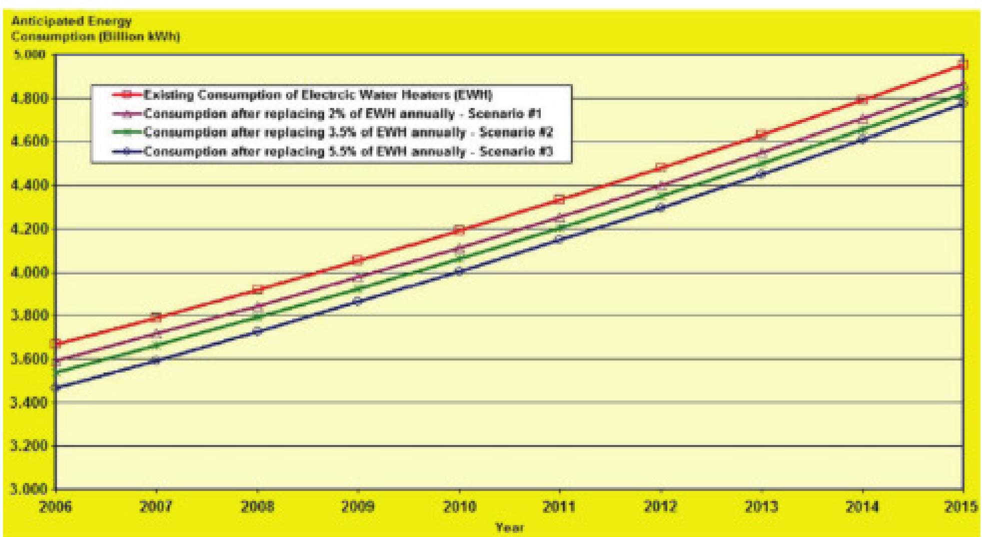



**Figure 27: Projected Electric Water Heaters Energy Consumption and Anticipated Reduction Due To SWH Scenarios**

Source: Adel K. Khalil, et. al., 2010

The RE strategy is formulated based on the following goals:

- By year 2022 that 16% of energy demand be supplied from RET excluding large hydropower systems; and the installment of 1.8 million $m^2$ of SWH systems.
- By year 2050 50% of electricity production comes from RE.

Potential share of local manufacturers of RE equipment

| | |
|---|---|
| Wind energy | 40,60 |
| Solar water heaters, | 70,95 |
| Photovoltaic systems, | 20,30 |
| Biomass | 50,95 |
| Concentrated solar power | 30,50 |

Expected savings in fossil fuel resources and emission reduction due to the implementation of the action plan for local manufacturing of RET systems and components.

**Table 7: Generated Energy via Renewable Energy**

| Technology of power generation | Anticipated savings | | Anticipated cost savings (million US$) | | Anticipated avoided subsidy (million US$) | | Generated energy via RET (million kWh) |
|---|---|---|---|---|---|---|---|
| | TOE (million) | $CO_2$ (million tons) | Opportunity cost for export | Certified emission reduction | Business as usual | Fuel prices liberation to close the gap | |
| *High scenario* | | | | | | | |
| Wind | 67 | 179 | 17,299 | 1789 | 13,311 | 5292 | 293,608 |
| CSP | 10 | 27 | 2656 | 275 | 2043 | 751 | 45,070 |
| PV | 1 | 3 | 258 | 27 | 199 | 62 | 4380 |
| Total | 78 | 209 | 20,213 | 2090 | 15,553 | 6105 | 343,059 |
| *Medium scenario* | | | | | | | |
| Wind | 46 | 122 | 11,830 | 1223 | 9103 | 3648 | 200,776 |
| CSP | 7 | 17 | 1680 | 174 | 1293 | 485 | 28,514 |
| PV | 0.6 | 1.5 | 142 | 15 | 109 | 34 | 2,409 |
| Total | 53 | 141 | 13,652 | 1412 | 10,505 | 4167 | 231,699 |
| *Low scenario* | | | | | | | |
| Wind | 22 | 59 | 5728 | 592 | 4408 | 1840 | 97,222 |
| CSP | 4 | 10 | 975 | 101 | 751 | 283 | 16,556 |
| PV | – | – | – | – | – | – | – |
| Total | 26 | 69 | 6704 | 693 | 5158 | 2123 | 113,778 |

Source: Adel K. Khalil, et. al., 2010

- Business as usual
- Fuel prices liberation to close the gap

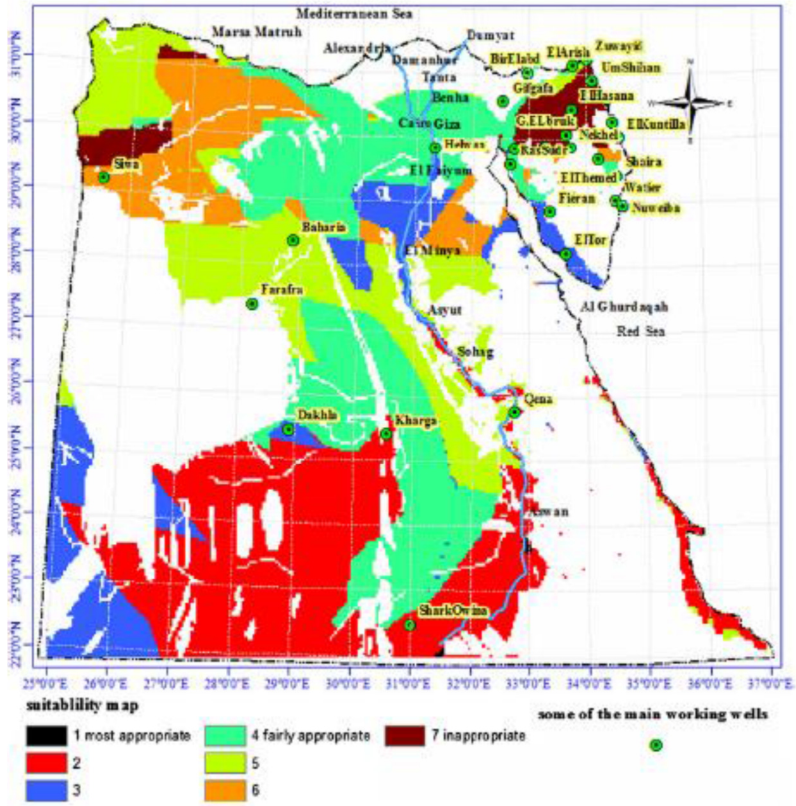



**Figure 28: Sustainability Map for PVP**

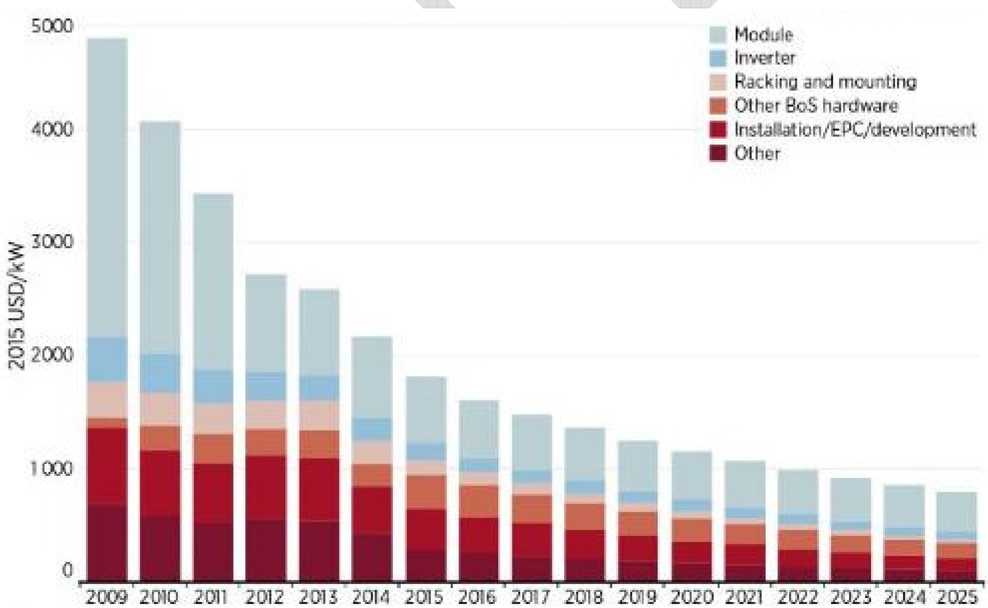



**Figure 29: Global weighted average Total System Costs Breakdown of Utility Scale Solar PV Systems, 2009 -2025**

Source: IRENA, 2016

## 7.9 Modeling of Data to Estimate the Potential Solar Pumps Market in Egypt

### *7.9.1 Market Size for Surface Water Lifting Pumps*

The surface water lifting pumps are relatively having small power compared to those lifting (withdrawing) from groundwater aquifers.

#### *7.9.1.1 Introduction*

**The main source of water supply** in the Wadi, Delta and some new lands is the Nile River that provides total water demand of the command area. Nile waters are delivered to the agriculture area through a complicated-well-organized system established over 150 years ago. The system consists of four grades of open canals; main, branch, distribution, and field canals which is located inside the farm. Surface irrigation system suffers from water shortage at Canal Tail-end. Water shortage at tail-end is caused mainly by improper maintenance of canals and growing crop patterns requiring extra amount of irrigation water than the designed canal discharge. In this case farmers are converted to lift water from agriculture drains or use shallow groundwater aquifers to compensate the water shortage. The common pump power is varied from 6, 8, 10, 12 and 16 hp. The 12 and 16 hp pumps are mainly used to lift water from shallow groundwater aquifers rather than lift water from surface canals.

Diesel fuel constitutes the main energy source to operate the pumps that are installed at the head of Mesqa to divert water from branch canal to Mesqa. Water is then made available to farmer fields, through openings along the Mesqa, which flows by gravity to fields. Water flows from main canals to branch canals primary, secondary and distributary canals by gravity.

The problem of converting the diesel irrigation pumps is complex since there are four major categories of people who are using the irrigation pumps, those categories are:

1- Farmers used Nile Water (surface water) in old lands;
2- Farmers using Groundwater (shallow aquifer) in old lands;
3- Farmers used Nile Water (surface water) in New lands;
4- Farmers using Groundwater (Medium and deep aquifers) in new lands;

#### *7.9.1.2 Ownership level in Old and New Lands based on the Source of Irrigation Water*

The area of irrigated land in addition to the number of land tenure (land possession) is listed in the following two tables. It can be recognized that in old land about 5.2 Million Feddans are owned by 4.0 Million farmer with an average level of land possession by 1.3 Feddan per farmer who are owning less than 1 Feddan up to 7 Feddans with an average value of 13 Feddan per farmer. However, in old land also 1.8 Million Feddan are owned by 88000 farmers who are having 10 Feddan and more with an average value of 20 Feddan by a farmer. This issue is very significant when conducting the required analysis for knowing the market size since it is essential to have the relationship between the level of ownership that beyond it the farmer can support the cost of converting from diesel power to solar power due to the assets cost of transferring. On the other hand, the area in old land that are using groundwater with an land possession started from 10 Feddan and

More is 1.0 million Feddan with an average value of ownership per farmer of 33 Feddan. On the other hand the ownership level is 1.7 Feddan per farmer for the level of possession started by less than 1 Feddan up to 7.0 Feddan per farmer. Table (8 and 9) present the level of possession for the **old land** (Wadi and Delta) irrigated by Nile Water (surface water) and Groundwater and in new land respectively. Table (10) presents the average area owned by farmers in old land and new land based upon the ownership level**.**

**Table 8: The Level of Possession for the Old Land (Wadi and Delta) Irrigated by Nile Water (Surface Water) and Groundwater**

| Land Tenure Level | Area of Irrigated from Nile Water Old-Lands (Feddan) | Number of Land Tenure (Land Possession) Using Nile Water | Area of Irrigated from Groundwater Water Old-Lands (Feddan) | Number of Land Tenure (Land Possession) Using Ground Water in Old Land |
|---|---|---|---|---|
| less than 1 | 884000 | 2055000 | 29000 | 69000 |
| 1 | 1233000 | 1003000 | 53000 | 49000 |
| 2 | 1061000 | 485000 | 53000 | 29000 |
| 3 | 634000 | 202000 | 43000 | 17000 |
| 4 | 344000 | 84000 | 33000 | 10000 |
| 5 | 713000 | 134000 | 78000 | 18000 |
| 7 | 345000 | 45000 | 58000 | 10000 |
| 10 | 495000 | 46000 | 93000 | 11000 |
| 15 | 243000 | 16000 | 66000 | 6000 |
| 20 | 306000 | 15000 | 98000 | 6000 |
| 30 | 225000 | 7000 | 91000 | 4000 |
| 50 | 132000 | 3000 | 94000 | 2000 |
| 100 | 109000 | 800 | 194000 | 2000 |
| 500 | 36000 | 50 | 70000 | 150 |
| More than 1000 | 217000 | 100 | 334000 | 150 |
| Total | 6977000 | 4095950 | 1387000 | 233300 |

**Table 9: The Level of Possession for the New Land Irrigated by Nile Water (Surface Water) and Groundwater**

| Land Tenure Level | Area of Irrigated from Nile Water New-Lands (Feddan) | Number of Land Tenure (Land Possession) Using Nile Water | Area of Irrigated from Groundwater Water New-Lands (Feddan) | Number of Land Tenure (Land Possession) Using Ground Water in Old Land |
|---|---|---|---|---|
| less than 1 | 3000 | 6000 | 350 | 900 |
| 1 | 21000 | 17000 | 3000 | 3000 |
| 2 | 70000 | 32000 | 5000 | 3000 |
| 3 | 36000 | 12000 | 6000 | 2000 |
| 4 | 38000 | 10000 | 6000 | 2000 |
| 5 | 221000 | 43000 | 28000 | 6000 |
| 7 | 60000 | 8000 | 23000 | 3000 |
| 10 | 129000 | 13000 | 44000 | 5000 |
| 15 | 66000 | 5000 | 35000 | 3000 |
| 20 | 109000 | 6000 | 58000 | 3000 |
| 30 | 76000 | 3000 | 59000 | 2000 |
| 50 | 50000 | 1000 | 65000 | 2000 |
| 100 | 63000 | 500 | 171000 | 2000 |
| 500 | 26000 | 50 | 66000 | 150 |
| More than 1000 | 217000 | 70 | 327000 | 150 |
| Total | 1185000 | 156620 | 896350 | 37200 |

**Table 10: Average Area Owned by Farmers in Old Land and New Land Based Upon the Ownership Level**

| Level of ownership | Average Area Owned by Farmer (Surface Water -Old Land) (Feddan/Farmer) | Average Area Owned by Farmer (Groundwater -Old Land) (Feddan per Farmer | Average Area Owned by Farmer (Surface Water -New Land Land) Feddan per Farmer | Average Area Owned by Farmer (Groundwater -New Land Land) Feddan per Farmer |
|---|---|---|---|---|
| less than 1 Feddan to 7 Feddans | 1.3 | 1.7 | 3.5 | 3.6 |
| 10 Feddans to 1000 Feddans | 13 | 33 | 18 | 25 |

### *7.9.1.3 Net Return Per Feddan from Different Crops*

In the following section, the net return per Feddan for all of the crops in Egypt is studied and analyzed. Thus, based on the Net-Return of the unit area of each crops a chart is plotted to identify the most reliable area that a farer owns can cover the assets cost of converting the diesel pump to PV system. According to the field visits (Annex 1) the were conducted during the course of the current study and the technical and financial offers that were received from different companies who are working in the field of PV, the price of a PV pump for surface or submersible pumps costs an average value of 60000 LE (based on 2016 prices = 7500 US $). Thus, it is essential to know which crop and the area of land that can cover the cost of converting to PV system (without batteries for power storage). An analysis for the entire crops in the country were conducted for a total number of 62 crops that includes the summer, winter and nili seasons. The results are summarized in Figure (30). List of consulted solar pump farms is presented in Annex 2.

**Table 11: Summary of net return per Feddan from some crops and the ownership level**

| Crops | Economic value LE / Feddan | Area in Feddan to cover the converting to PV Cost | Crop Cultivation Period |
|---|---|---|---|
| Tomato | 20000-22000 | 3 | Seasonal |
| Eggplant, Okra | 10000-12000 | 5-6 | Seasonal |
| Apple, sugarcane | 9000-10000 | 6 | Annual |
| Squash, Aniseed, water melon | 8000-9000 | 8-9 | Seasonal |
| Banana, Mango, citrus | 7000-8000 | 9-10 | Annual |
| Wheat, sugar beet | 4000 | 16 | Seasonal |
| Legumes, cotton | 1200-1600 | 40-50* | Seasonal |

*Indicates that the two pumps or more are needed since the area became more than the capacity of single pump

Accordingly, it can be concluded that the following points are important for analyzing the market of PV pumps:

1- The crop type is very significant for converting without any type of financial support. Vegetables and fruits are very suitable crop type for converting the system to PV in one or two seasons.
2- Farmers who are used to cultivate wheat and oily crops need a special support for converting to PV.
3- Cotton and legumes are coming in the lowest level since the net return from these crops are relatively very low and cannot support the transfer to PV system.
4- The optimum area that the market can be opened for should be calculated.

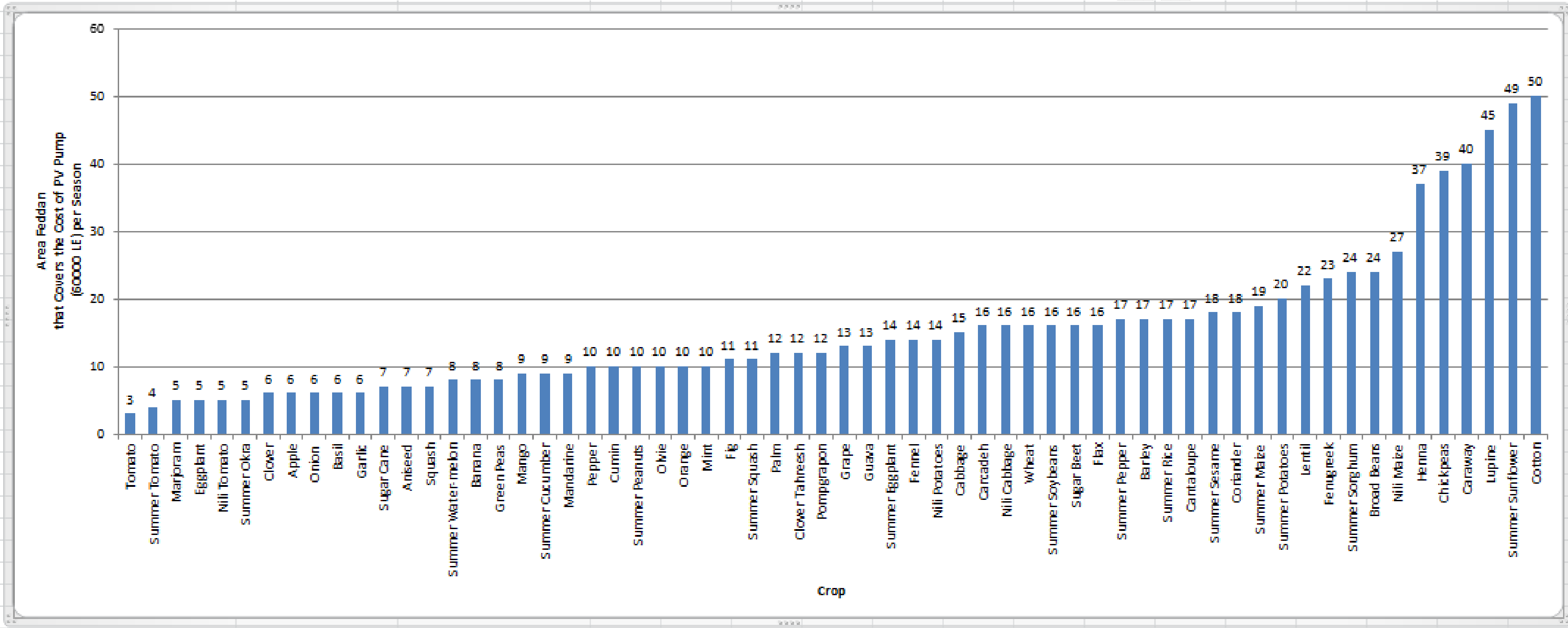



**Figure 30: The Number of Feddans through Which the Owner Can Cover the Cost of Converting to PV Pump System Tied to the Type of Crop**

#### *7.9.1.4 The Optimum Ownership Level to Support the Converting to PV System*

**Table 12: List of the Most Promising Crops to Support the Converting To PV without Financial Support (Considering the Cultivation Area of 10 Feddans and More)**

| Rank | Crop | Rank | Crop | Rank | Crop |
|---|---|---|---|---|---|
| 1 | Tomato | 11 | Garlic | 21 | Pepper |
| 2 | Summer Tomato | 12 | Sugar Cane | 22 | Cumin |
| 3 | Marjoram | 13 | Aniseed | 23 | Summer Peanuts |
| 4 | Eggplant | 14 | Squash | 24 | Olive |
| 5 | Nili Tomato | 15 | Summer Water-melon | 25 | Orange |
| 6 | Summer Okra | 16 | Banana | 26 | Mint |
| 7 | Clover | 17 | Green Peas | 27 | Fig |
| 8 | Apple | 18 | Mango | 28 | Summer Squash |
| 9 | Onion | 19 | Summer Cucumber | 29 | Palm |
| 10 | Basil | 20 | Mandarin | 30 | Clover Tahreesh |

Based on the results listed in Tables (11), Table (12) and Figure (30), a complete survey for the number of pumps all over the country with different levels has found to be 118000 pumps as listed in Table (13).

**Table 13: An Inventory for the Number of Pumps Expected to be converted to PV System (Ownership Level 10 Feddans and More).**

| Pump Power | Number of Pumps | Lifting from |
|---|---|---|
| 6 hp | 21000 | Surface Water |
| 6-12 hp | 53000 | Surface/Ground |
| 16 and More hp | 16000 | Ground |
| Electrical Motor | 26000 | Surface/Ground |
| Total | 116000 | |

The inventory for the different governorate shows that El-Behera governorate has 36000 pumps that can be converted, 12000 of this number is located in the New Land area and 24000 is located in the old area in delta. El-Sharkeya and Kafr El-Sheikh are having a range of 11000 pumps for each. Table (14) presents all of the governorates of Egypt and the number of pumps that can be converted to PV system in both old land and new land. Table (15) presents the total number of pumps to be converted to PV compared to the total number of pumps within the governorate. The percentage of converting from Diesel Fuel to PV within the different governorates can be summarized in the following points:

1- For old land in Wadi and Delta the proposed number of pumps to be converted is representing a range between 2.5 % – 9 % from the total pumps with an average value of 5% from the total number.

2- For the governorates that have a new land expansion the number of pumps that can be converted is in the range of 20%, these governorates are Ismaliya, port Said, North Sinai.
3- For El-WAdi El-Gedid, El-Wahat area the range of pumps to be converted reach to 75%.

**Table 14: Numbers and Category of Pumps to be Converted to PV Allover Egypt**

| Governorate | New Land | | | | Old Land (Wadi and Delta) | | | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | 6 hp | 6-16 hp | 16 hp and more | Electrical Irrigation Pump | 6 hp | 6-16 hp | 16 hp and more | Electrical Irrigation Pump | |
| *El-Behera* | 1355 | 3902 | 1987 | 5047 | 4565 | 10325 | 2841 | 6143 | 36165 |
| *Sharkia* | 0 | 0 | 0 | 0 | 1358 | 4271 | 2061 | 3519 | 11209 |
| *Kafr El-Sheikh* | 699 | 1905 | 300 | 119 | 2453 | 4547 | 578 | 300 | 10901 |
| *Ismailia* | 0 | 0 | 0 | 0 | 680 | 3548 | 625 | 1996 | 6849 |
| *Dakhalya* | 0 | 0 | 0 | 0 | 1197 | 3601 | 1467 | 206 | 6471 |
| *El Minia* | 192 | 359 | 68 | 68 | 1224 | 3438 | 247 | 175 | 5771 |
| *El Menoufia* | 23 | 202 | 1038 | 22 | 195 | 1359 | 1261 | 323 | 4423 |
| *Alexandria* | 213 | 1031 | 244 | 116 | 324 | 1569 | 313 | 169 | 3979 |
| *Beni Suef* | 260 | 446 | 6 | 127 | 829 | 1373 | 80 | 234 | 3355 |
| *Port Said* | 0 | 0 | 0 | 0 | 697 | 1223 | 894 | 23 | 2837 |
| *Assuit* | 0 | 18 | 70 | 268 | 175 | 1031 | 358 | 858 | 2778 |
| *Noth Sinai* | 0 | 0 | 0 | 0 | 386 | 338 | 61 | 1707 | 2492 |
| *Domitta* | 0 | 0 | 0 | 0 | 970 | 1099 | 193 | 39 | 2301 |
| *Sohag* | 0 | 0 | 0 | 0 | 447 | 995 | 510 | 200 | 2152 |
| *Qena* | 38 | 53 | 65 | 26 | 255 | 1056 | 329 | 152 | 1974 |
| *El- gaherbya* | 0 | 0 | 0 | 0 | 406 | 1363 | 72 | 102 | 1943 |
| *6-October* | 189 | 447 | 408 | 886 | 0 | 0 | 0 | 0 | 1930 |
| *Wadi El- geded* | 188 | 195 | 22 | 66 | 219 | 221 | 34 | 981 | 1926 |
| *Fayoum* | 4 | 58 | 47 | 74 | 357 | 699 | 111 | 307 | 1657 |
| *Aswan* | 62 | 558 | 25 | 18 | 99 | 699 | 38 | 68 | 1567 |
| *Qalyubia* | 1 | 0 | 0 | 0 | 155 | 692 | 137 | 95 | 1080 |
| *Helwan* | 132 | 75 | 34 | 587 | 0 | 0 | 0 | 0 | 828 |
| *Suez* | 0 | 0 | 0 | 0 | 76 | 583 | 57 | 56 | 772 |
| *South Sinai* | 0 | 0 | 0 | 0 | 11 | 188 | 5 | 29 | 233 |
| *Marsa Matrouh* | 2 | 37 | 5 | 6 | 0 | 0 | 0 | 0 | 50 |
| *Giza* | 0 | 0 | 0 | 0 | 1 | 25 | 5 | 2 | 33 |
| *Cairo* | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 14 | 18 |
| *Red Sea* | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 2 |
| Total | 3358 | 9286 | 4320 | 7431 | 17079 | 44245 | 12279 | 17698 | 115696 |

**Table 15: Numbers and Category of Pumps to be Converted to PV Allover Egypt Compared to the Total Number of Pumps within Each Governorate**

| Governorate | Total No of Pumps | Total No 6 HP | Total No 6-16 HP | Total No More 16 HP | Total Electrical (12 HP) | total Governorate | % of total from total gov. |
|---|---|---|---|---|---|---|---|
| El-Behera | 36165 | 5920 | 14227 | 4828 | 11190 | 1401388 | 2.6 |
| Sharkia | 11209 | 1358 | 4271 | 2061 | 3519 | 174057 | 6.4 |
| Kafr El-Sheikh | 10901 | 3152 | 6452 | 878 | 419 | 230132 | 4.7 |
| Ismailia | 6849 | 680 | 3548 | 625 | 1996 | 33606 | 20.4 |
| Dakhalya | 6471 | 1197 | 3601 | 1467 | 206 | 165149 | 3.9 |
| El Minia | 5771 | 1416 | 3797 | 315 | 243 | 103757 | 5.6 |
| El Menoufia | 4423 | 218 | 1561 | 2299 | 345 | 95730 | 4.6 |
| Alexandria | 3979 | 537 | 2600 | 557 | 285 | 17803 | 22.4 |
| Beni Suef | 3355 | 1089 | 1819 | 86 | 361 | 87502 | 3.8 |
| Port Said | 2837 | 697 | 1223 | 894 | 23 | 13225 | 21.5 |
| Assuit | 2778 | 175 | 1049 | 428 | 1126 | 43268 | 6.4 |
| Noth Sinai | 2492 | 386 | 338 | 61 | 1707 | 9866 | 25.3 |
| Domitta | 2301 | 970 | 1099 | 193 | 39 | 44577 | 5.2 |
| Sohag | 2152 | 447 | 995 | 510 | 200 | 52518 | 4.1 |
| Qena | 1974 | 293 | 1109 | 394 | 178 | 28564 | 6.9 |
| El- gaherbya | 1943 | 406 | 1363 | 72 | 102 | 160522 | 1.2 |
| 6 october | 1930 | 189 | 447 | 408 | 886 | 2489 | 77.5 |
| Wadi El-geded | 1926 | 407 | 416 | 56 | 1047 | 7703 | 25.0 |
| Fayoum | 1657 | 361 | 757 | 158 | 381 | 19553 | 8.5 |
| Aswan | 1567 | 161 | 1257 | 63 | 86 | 14971 | 10.5 |
| Qalyubia | 1080 | 156 | 692 | 137 | 95 | 39857 | 2.7 |
| Helwan | 828 | 132 | 75 | 34 | 587 | 1293 | 64.0 |
| Suez | 772 | 76 | 583 | 57 | 56 | 5513 | 14.0 |
| South Sinai | 233 | 11 | 188 | 5 | 29 | 1794 | 13.0 |
| Marsa Matrouh | 50 | 2 | 37 | 5 | 6 | 2204 | 2.3 |
| Giza | 33 | 1 | 25 | 5 | 2 | 953 | 3.5 |
| Cairo | 18 | 0 | 1 | 2 | 15 | 181 | 9.9 |
| Red Sea | 2 | 0 | 1 | 1 | 0 | 78 | 2.6 |

# 8. Proposal of indicative solar pumping targets and market growth paths by 2020, 2025 and 2030, in line with relevant national objectives

## 8.1 PV Market for Future in Egypt

### *8.1.1 Mega Agriculture Development Projects in Egypt using PV*

Under the 1st Priority Land Reclamation Projects of the New Land development in Egypt, it is planned to reclaim 1.0 Million Feddan of agricultural land in nine reclamation areas in the Western Desert. 876,000 Feddan will be irrigated with groundwater. Afterward, the project is extended to cover 1.5 million feddan at the first stage. The groundwater is being extracted from the large water bearing formations constituted by extensive the Nubian Sandstone Aquifer (NSA) and the overlying Post Nubian Aquifers Systems (PNAS). The full scale implementation of the project will require the mobilization of 4.38 BCM of groundwater annually, in addition to the quantities of groundwater currently developed from wells and springs estimates to be higher than 1 billion $m^3$/yr. The Project is in line with the Government's "Strategic Framework for Economic and Social Development Plan until Year 2022" as well as with the "Sustainable Agricultural Development Strategy towards 2030".

Solar photovoltaic, grid extension and diesel generators in combination seem to be the best options for providing reliable and sustainable electricity to lift water at the required heads and for the required volume. PV prices have sharply been decreased to levels below US$ 1.0/Wp the fact that makes this technology show better economic feasibility over diesel systems for small, medium and sometimes large scale sizes. Furthermore, in a remote area; such as new agriculture projects in Egypt (1.5 Million Feddan project); projects site where a lack of electrical grid is, PV energy is highly comparative over diesel generators. However, dust must be removed from the glass plates of the module regularly. In addition, external wires, the supporting structure of the array, covers for the electronic components, and a fence may need occasional repairs. Wood or metal parts that are sensitive to corrosion must be painted every year.

As mentioned in the first chapters in the current report, Egypt water policy is being developed to augment the water supplies especially in the newly developed areas located away from the Nile. The Western and Eastern Deserts of Egypt are characterized by different water resources features. In the Western Desert, the deep Nubian Sandstone Aquifer constitutes the only water resource and is currently utilized in the scattered oasis. In such oasis, groundwater is naturally flowing from the natural springs and from the deep and shallow groundwater wells. It is worth mentioning that rainfall is very limited and surface water runoff never occurs due to the low slope of the ground surface as well as the high infiltration rate of the top soil.

The economic utilization of the available groundwater is constrained by three major factors, which are the cost of drilling, the required energy to lift the water to the ground surface and its quality. With full consideration of these three factors along with the other strategic dimensions, the optimal locations of the developed areas were identified.

The planned reclamation area is 4 million Fadden throw 4 years. The first phase includes reclamation and cultivation area for 1.0 Feddan. All of them will be irrigated by groundwater as listed in Table (16). The Ministry of Water Resources and Irrigation made an indispensable study to ensure the availability of water for irrigating proposed areas Figure 31 shows the proposed locations of four million feddan reclamation projects. There are a decree issued from Ministry of Water Resources that all of these wells has to use the PV system.

**Table 16: New Reclamations Area depends on Groundwater Wells that currently executed out of the 4 Million Feddan project**

| Location | Agriculture Area 1000 Feddan | Number of Wells | Well Depth (m) |
|---|---|---|---|
| Toshka | 10 | 100 | 250 |
| Moghra | 150 | 1352 | 200 |
| Old Farafra | 92 | 480 | 1000 |
| New Farafra | 20 | 100 | 1000 |
| East Owinat | 100 | 800 | 400 |
| West Menia | 420 | 1450 | 1000 |
| South Qattara | 50 | 220 | 1200 |
| Siwa | 30 | 120 | 1200 |
| Total | 872 | 4622 | |



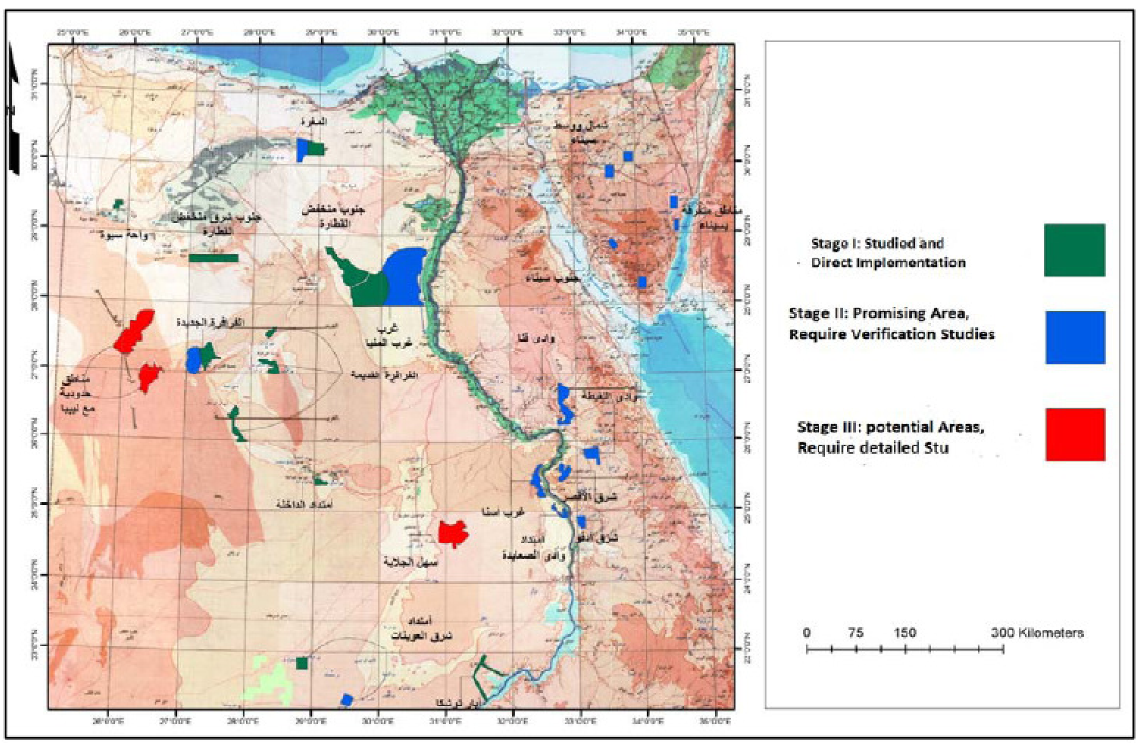



**Figure 31: Location of the four Million Feddan Project**

### *8.1.2 The PV market in Old Land (Wadi and Delta) and in New Land (Reclaimed 1985-2010)*

Table (17) presents the total number of PV.

**Table 17: Total Number of PV**

| Pump Power | Number of Pumps | Lifting from |
|---|---|---|
| 6 hp | 22000 | Surface Water |
| 6-12 hp | 53000 | Surface/Ground |
| 16 and More hp | 16000 | Ground |
| Electrical Motor | 27000 | Surface/Ground |
| Total | 118000 | |

### *8.1.3 The PV Market for Well Pumps Owned by Ministry of Water Resources*

According to the investigation and data collection it has been found that the Electro-Mechanical department within the Ministry of Water Resources is the responsible department for constructing, operating and maintenance of irrigation and drainage pumps in Egypt. The final target of pumps that can be converted to PV system is in the range of 600 pumps. These pumps are mainly located in EL-Wadi El-Gedid and El-Wahat area. The remaining pumps are 1000 pumps most of these pumps are used for lifting water from lower level to higher level from Nile river to canals, canal to canal, drain to drain, drain to canal, drain to lake and drain to sea. These type of pumps are relatively very large or medium level. Those pups needs very large areas for solar power that most probably are not available in Wadi and Delta region. In addition these system has to be operated full 24 – hours thus it is not considered reliable for converting to PV system. Accordingly, the total number available mounted on groundwater wells.

### *8.1.4 Total number of Irrigation Pumps to be converted to PV system*

Table (18) summarizes the total number of pumps that can be converted to PV system.

#### *8.1.4.1 Mega Agriculture Development Projects*

For the 1.5 Million Feddan Project the total number of pumps needed is **3810** submersible pump. The pumps are three categories : the first category is 20-30 kW with a number of 630 pumps; the second category is 40-70 kW with a number of 91 pumps; the third category is 77 kW with a number of 120 kW and the last category is 175 kW with a number of 220. Thus, the area that will be served by these pumps is 1.012 Million Feddan.

**Table 18: Total Number of PV Pumps and its Power required for the Mega Project**

| Location | Total Surface Area (1000 Feddan) | Expected Dynamic Head (m) | Discharge (m3/hr) | Number of Submersible Pumps | Required Power kW for Pumps |
|---|---|---|---|---|---|
| Toshka | 10 | 70-80 | 100 | 102 | 22 |
| Moghra | 150 | 40-110 | 80 | 1352 | 24 |
| New Farafra | 20 | 30-40 | 250 | 20 | 28 |
| East Menia | 440 | 40-60 | 200 | 1500 | 32 |
| OldFarafra | 92 | 30-60 | 250 | 96 | 41 |
| Owinat | 50 | 70-90 | 200 | 400 | 50 |
| Siwa | 30 | 35 | 800 | 120 | 77 |
| South Qatarah | 220 | 80 | 800 | 220 | 175 |

### *8.1.4.2 Wadi, Delta and New Land (reclaimed from 1985-2015)*

From the previous analysis, it has been concluded that the total number of pumps is 118000 pumps.

**Table 19: Pumps to be Converted to PV system in Wadi and Delta**

| Pump Power | Number of Pumps | Lifting from |
|---|---|---|
| 6 hp | 22000 | Surface Water |
| 6-12 hp | 53000 | Surface/Ground |
| 16 and More hp | 16000 | Ground |
| Electrical Motor | 27000 | Surface/Ground |
| Total | 118000 | |

The distribution of these pumps all over the different governorates is shown in the following four Figures. Figures (32) shows the distribution of the 6 hp, 6-16 hp, more than 16 hp and the electrical motor pumps.

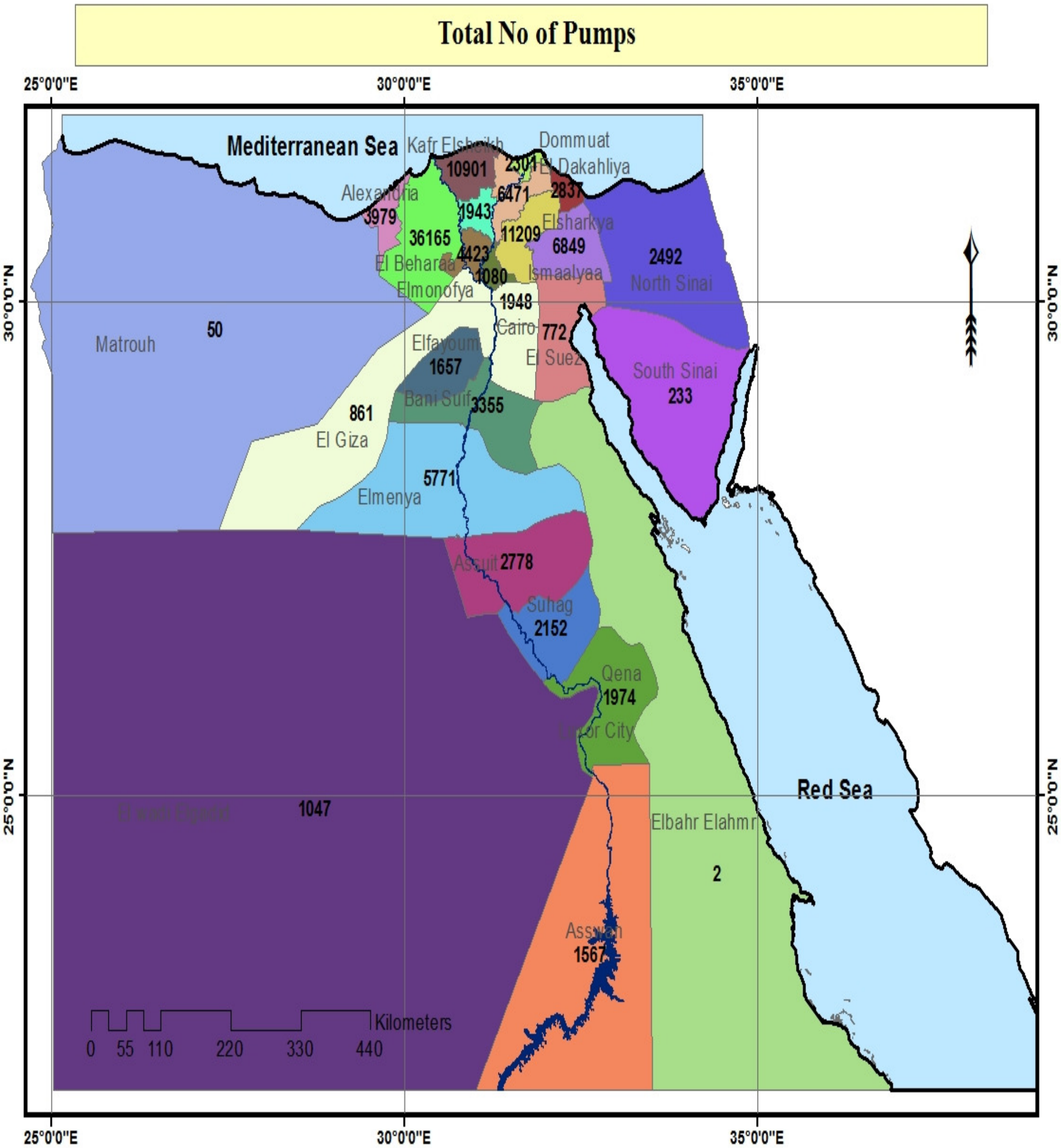



**Figure 32: Distribution of Total Number Irrigation Pumps to be Converted to PV System at each Governorate.**

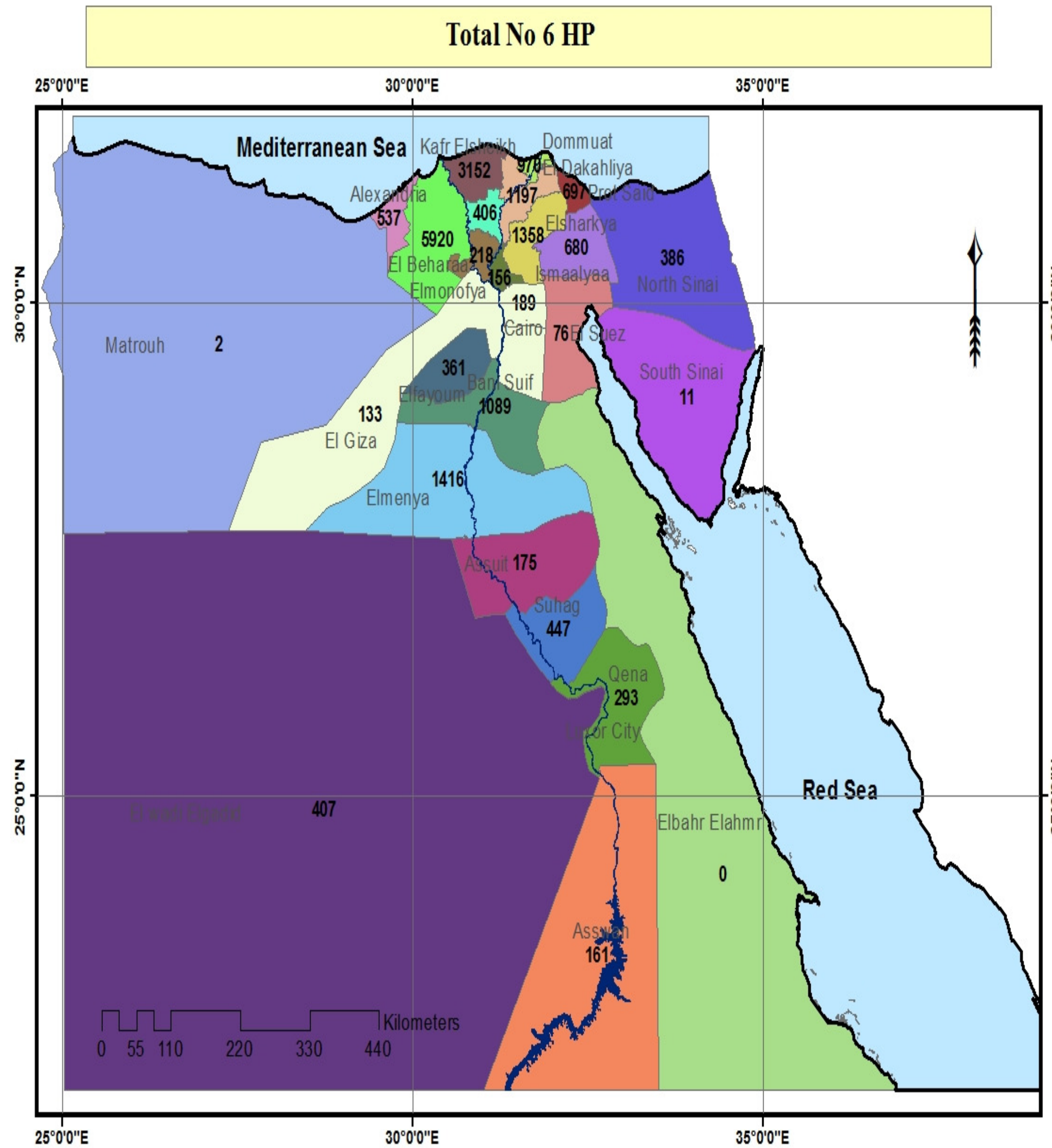



**Figure 33: Distribution of Relatively Small Horsepower Pumps 6 hp (Surface water / Groundwater lifting) all over the Country**

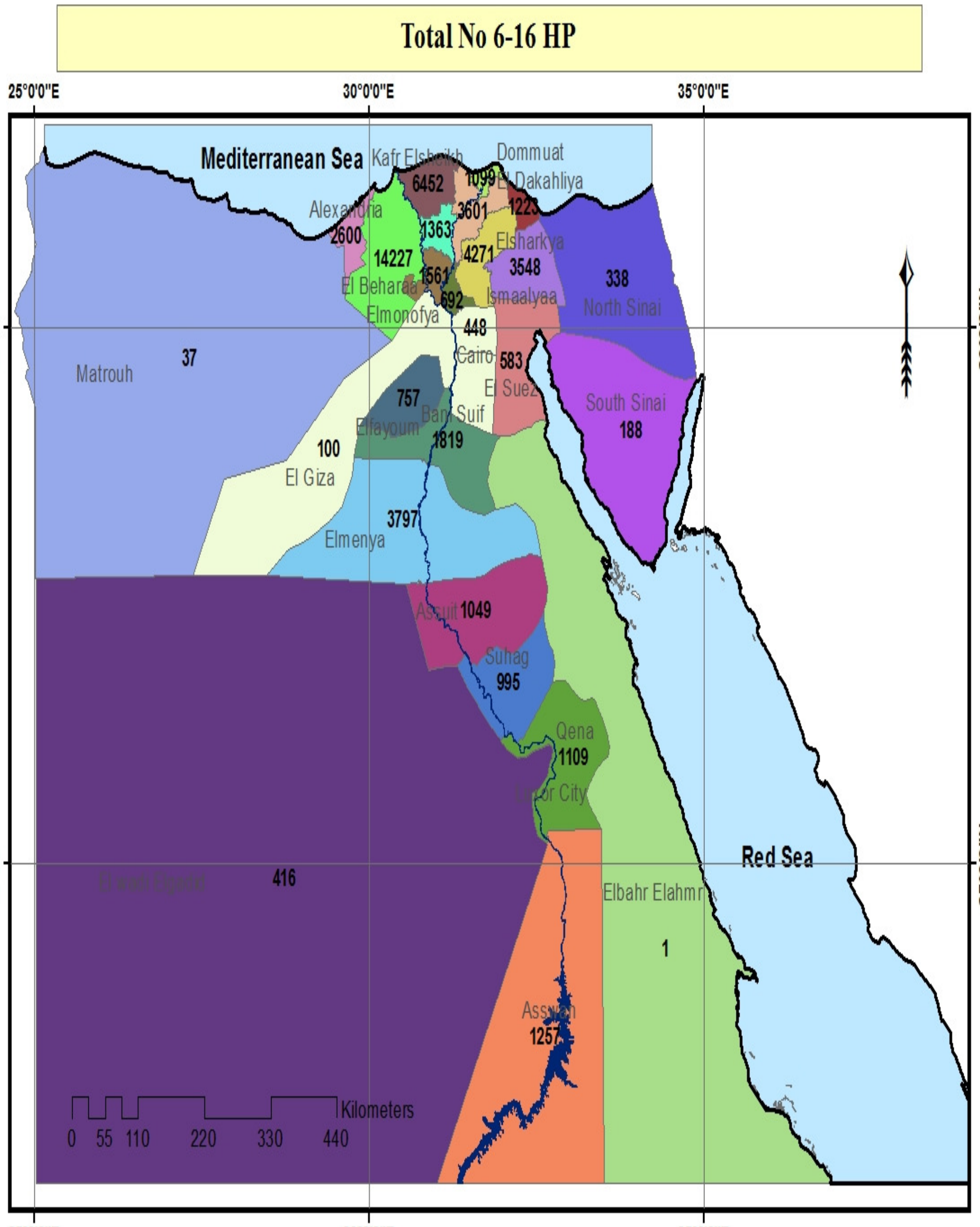



**Figure 34: Distribution of Relatively Small Horsepower Pumps 6 hp-16 hp (Surface water / Groundwater lifting) all over the Country**

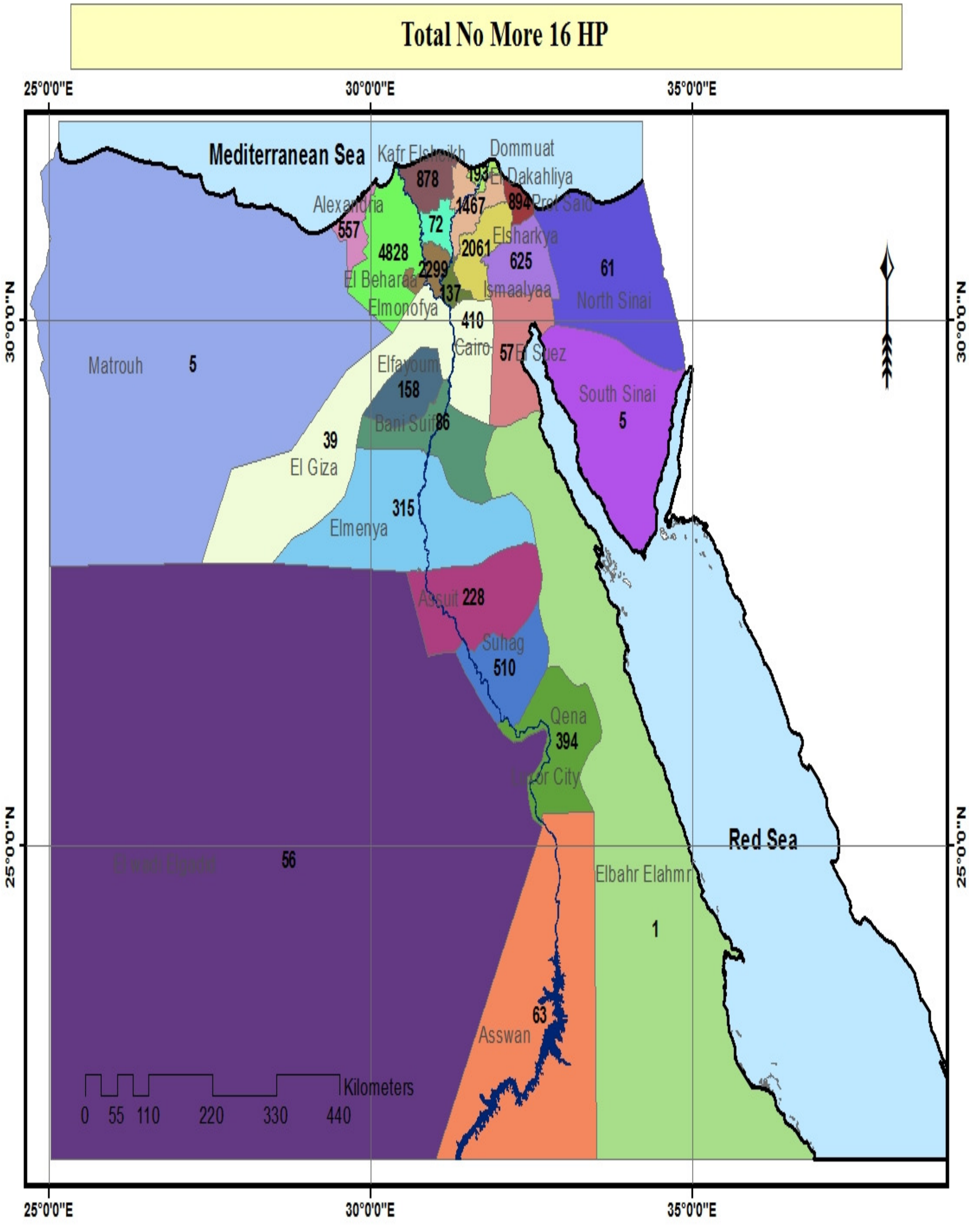



**Figure 35: Distribution of Relatively Small Horsepower Pumps 16 hp (Groundwater lifting) all over the Country**

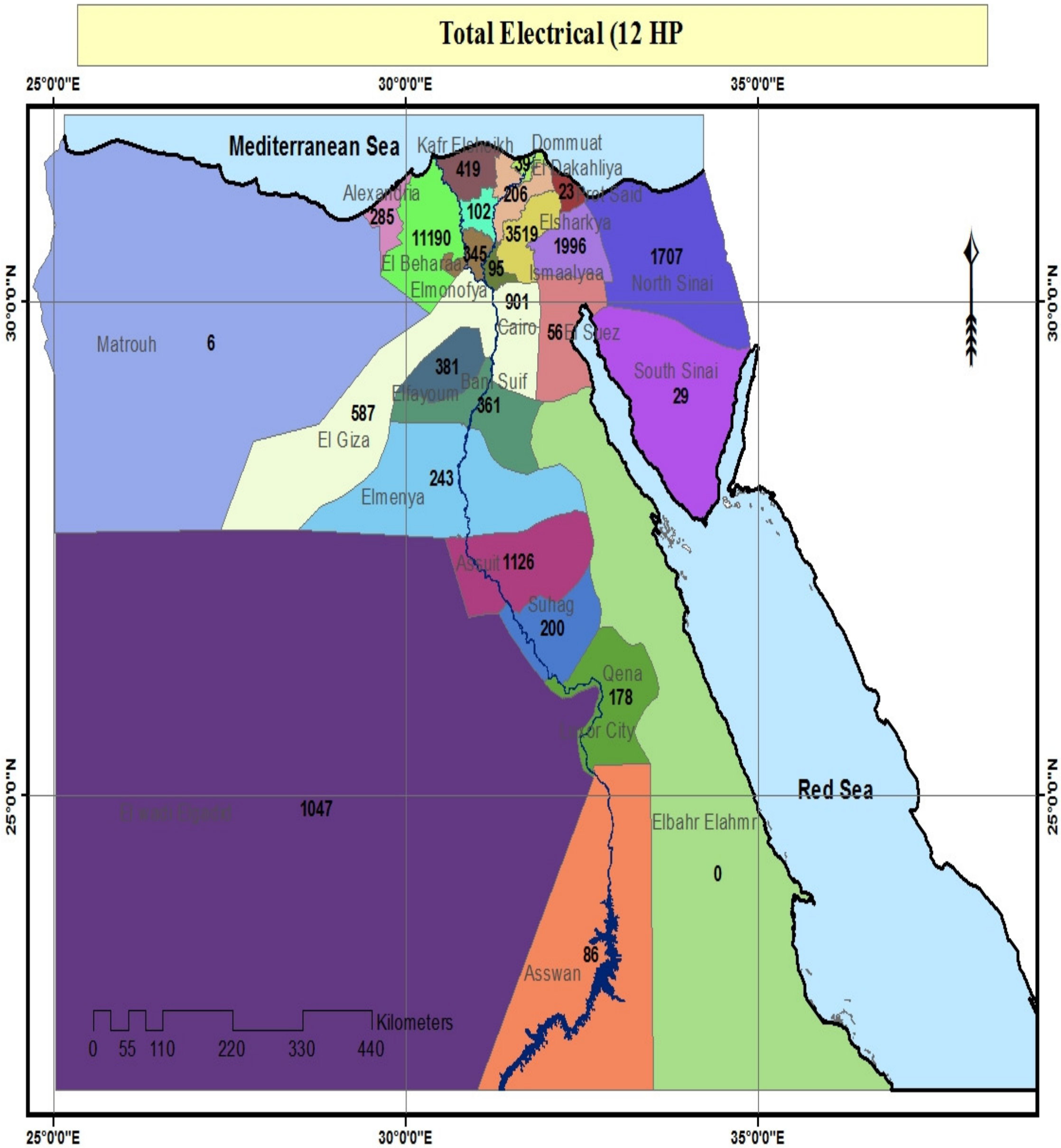



**Figure 36: Distribution of Relatively Electrical Pumps 16 hp (Groundwater lifting) all over the Country**

### *8.1.4.3 Ministry of Water Resources Pumps*

The total number of pumps that to be converted to PV system is 600 pump in the Wahat and Wadi El-Gedid.

### *8.1.5 Market Size Model for Converting Diesel Pump to PV System*

The global solar market has been grown in several models. Figure (36) shows the global market trend lines. Trend Line 1 and trend line 2 are in the form of polynomial from 3rd or 4th degree. Trend Line 3 is the sigmoid function.

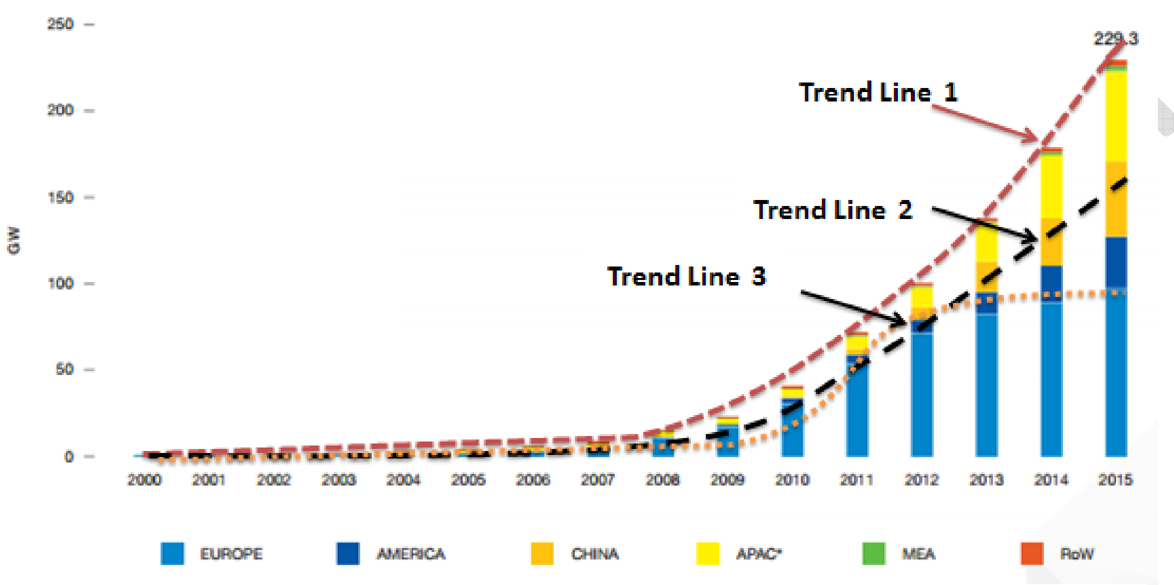



**Figure 37: Profile of Solar Energy Growth in Europe, America, China, Australia-Pacific from 2000 To 2015**

In the current study a polynomial of the 3rd order has been developed for the market of PV pumps that starts from 2017 to 2032. The following Table presents 7 selected scenarios for the market growth. The proposed 7 scenarios for market growth, all of these models are 3rd polynomial.

**Table 20: Summary of PV Market Assessment from 2017 to 2032**

| | Scen 1 | Scen 2 | Scen 3 | Scen 4 | Scen 4 | Scen 5 | Scen 6 | Scen 7 |
|---|---|---|---|---|---|---|---|---|
| 2017 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2018 | 500 | 1000 | 1500 | 2000 | 3000 | 4000 | 5000 | 6000 |
| 2019 | 1000 | 2000 | 3000 | 4000 | 6000 | 8000 | 10000 | 12000 |
| 2020 | 1500 | 3000 | 4500 | 6000 | 9000 | 12000 | 15000 | 18000 |
| 2021 | 2000 | 4000 | 6000 | 8000 | 12000 | 16000 | 20000 | 24000 |
| 2022 | 2500 | 5000 | 7500 | 10000 | 15000 | 20000 | 25000 | 30000 |
| 2023 | 3000 | 6000 | 9000 | 12000 | 18000 | 24000 | 30000 | 36000 |
| 2024 | 5000 | 10000 | 15000 | 20000 | 30000 | 40000 | 50000 | 60000 |
| 2025 | 8500 | 17000 | 25500 | 34000 | 51000 | 68000 | 85000 | 102000 |
| 2026 | 11500 | 23000 | 34500 | 46000 | 69000 | 92000 | 115000 | 138000 |
| 2027 | 22500 | 45000 | 67500 | 90000 | 135000 | 180000 | 225000 | 270000 |
| 2028 | 35000 | 70000 | 105000 | 140000 | 210000 | 280000 | 350000 | 420000 |
| 2029 | 50000 | 100000 | 150000 | 200000 | 300000 | 400000 | 500000 | 600000 |
| 2030 | 62500 | 125000 | 187500 | 250000 | 375000 | 500000 | 625000 | 750000 |
| 2031 | 87500 | 175000 | 262500 | 350000 | 525000 | 700000 | 875000 | 1050000 |
| 2032 | 115000 | 230000 | 345000 | 460000 | 690000 | 920000 | 1150000 | 1380000 |

| | |
|---|---|
| (orange) | 2017 Market Starting Point |
| (green) | Point of market satisfaction |

Accordingly, it can be concluded the following points:

1- According to the status quo scenario (1500= the starting point and it is equivalent to the entire available market of PV pumps in Egypt currently.
2- The model showed that the market shall be satisfied by year 2029
3- By increasing the initial potential market from 1500 pump in the first year, to 6000 pumps (scenario 7) the system can be satisfied not before 2026.

# 9. Recommendation of different polices and support measures to achieve the different targets

## 9.1 Parties responsible for Fulfillment of the Targets

The Government of Egypt represented by Ministry of Agriculture and Land Development Reclamation. Ministry of Water Resources and Irrigation and Ministry of Electricity and Energy have produced different strategic development plans for the next decades. The main outline points of each of the three ministries can be listed as follow:

**Ministry of Agriculture plans** recognized the need for increased production, reducing imports and weaving in value added activities in all phases of agricultural development.

**Ministry of Electricity and Energy** recognized the Contribution of renewable energies by 20% of the total electricity generation by the year 2020. The share from the grid-connected wind power is 12% of the total electricity generation, and that represents about 7200 MW total capacities. Also, other renewable energy applications, led by hydropower and solar energy, will have a significant contribution.

**Ministry of Water Resources and Irrigation** Water resources sector plans recognized the use of renewable energy for irrigation. The program is underpinned by increased emphasis on the sustainability of Egypt's natural resources, especially water. Projects to conserve and rationalize irrigation water use are in progress.

Egyptian policy makers pay special attention on the agricultural sector for its importance in ensuring food security to the rapidly growing population through the following activities:

- Better utilization of agricultural resources,
- Potential for new lands using drainage water reuse,
- Reuse of treated wastewater, (The rate of water liter re-consumption)
- Improvement of water use efficiency,
- Groundwater resources management,
- Rice Reduction,
- Development of horizontal expansion area through reclaiming new lands which require adopting good agricultural practices that depend on transfer of the knowhow technology.

Additional points are considered under the land reclamation program. The program emphasizes improving farmers' livelihood as well as the opportunities in off-farm employment particularly in the post-harvest chain and ancillary services. Improvement of agricultural services is taking on a higher priority particularly in new reclaimed lands.

## 9.2 Types of Financing Models

The far most of the financing for renewable energy for irrigation pumps has been proposed in the form of development assistance focused on providing technology in demonstration projects. The funds is proposed to be usually initiated and managed by the national government and external donor programs.

For PV irrigation pumps new financing models can be proposed based on local capacity and higher involvement of consumers. The best known are micro credit consumer programs for small-scale PV systems, and seed capital provision for small and mid-size enterprises (SMEs) to assist local entrepreneurs in starting up new businesses in clean energy products and services. In General, support the PV irrigation pumps will have to be induced by market-based incentives, allowing them to attract conventional sources of finance.

### *9.2.1 Financing models for PV Irrigation Pumps*

#### *9.2.1.1 Government-led model*

It is very common of the financing programs are still managed by a government body or donor organization, although the actual model can take on several different forms and include different market players.

The funding is proposing of a preferential loan scheme from the development banks (such as World Bank, European Investment Bank, Nasser Bank National Banks such as Al-Ahly Bank, and the money had to be repaid from the project's economic surplus. Moreover, the local community had to provide the financial means to pay for the operation, repair, maintenance and possible capacity expansion of the system.

#### *9.2.1.2 Local Community Model*

The local community had to provide the financial means to pay for the operation, repair, maintenance and possible capacity expansion of the system, and mostly a revolving fund was applied. This type of program is usually part of the national poverty alleviation policy, was not supported by international funding, but it turned out quite successful in developing a PV market in rural areas specially.

#### *9.2.1.3 Companies Model*

Companies were required to invest their own resources and users contributed both to the investment phase and during the operation of projects, to increase their commitment and to support adequate service and maintenance. Users had to cover partial of the costs.

#### *9.2.1.4 Market-based models*

Due to the perceived high risk and low return on investment for RE and EE projects, few success stories using a market-based model are available. However, international aid agencies have been developing several market-based business models, especially for rural electrification programs. To become economically viable with less or ultimately no governmental or donor support, RE and EE projects should strive to get embedded in conventional economic activity, by integrating more private actors in the process, by

gradually increasing income through the delivery of energy services and the differentiation of the client base.

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